Material Efficiency & Resource Conservation

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Material Use Indicators for Measuring Resource Productivity and Environmental Impacts

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Final report

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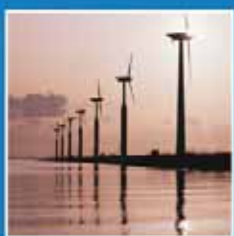



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Umwelt
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Material Use Indicators for Measuring Resource Productivity and Environmental Impacts

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Kurzfassung

Die Bundesregierung beabsichtigte, die Anwendung von Makroindikatoren zur Messung des Ressourcenverbrauchs der deutschen Wirtschaft zu untersuchen, und erwartete Vorschläge zur weitergehenden Anwendung und Entwicklung. Im erweiterten Kontext steht dies in Verbindung zur Entwicklung eines nationalen Programms für nachhaltiges Ressourcenmanagement wie es zum Beispiel durch die Thematische Strategie der EU zur nachhaltigen Nutzung natürlicher Ressourcen gefordert wird. Im Besonderen sollte das bestehende Instrumentarium zur Beobachtung des Fortschrittes hin zu Nachhaltigkeit im Sinne der nationalen Nachhaltigkeitsstrategie verbessert werden, indem der Gültigkeitsbereich des bisher verwendeten Rohstoffindikators zu erweitern wäre.

Die Konzepte der Materialflussrechnung von EUROSTAT und OECD beinhalten eine schrittweise Erweiterung der Indikatoren für Ressourcennutzung und Ressourcenproduktivität. Direkter Material Input (*englisch: Direct Material Input - DMI*) und Inländischer Materialverbrauch (*englisch: Domestic Material Consumption - DMC*) bilden die Basis, sie erfassen jedoch nicht die indirekten Materialflüsse von Importen und Exporten, und auch nicht die ungenutzte Extraktion im Inland. So werden die ausländische Dimension und der volle Umfang der Primärmaterialentnahme nicht abgebildet. DMI und DMC können in Rohstoffäquivalenten (*englisch: Raw Material Equivalents - RME*) berechnet werden, welche die indirekten Materialflüsse in Form genutzter Rohstoffentnahme einschließt und damit die nicht genutzte Extraktion außen vor lässt. Die umfassendsten Indikatoren für den gesamten globalen Primärmaterialbedarf für Produktion und Verbrauch, welche sowohl die genutzte als auch die nicht genutzte Extraktion umfassen, sind der Globale (Gesamt-)Material Aufwand (*englisch: Total Material Requirement - TMR*) und der Globale (Gesamt-)Material Verbrauch (*englisch: Total Material Consumption - TMC*).

Darüber hinaus beabsichtigt die Europäische Kommission Indikatoren zu entwickeln, welche die mit Ressourcennutzung verbundenen Umweltwirkungen abbilden, um so Fortschritte zur doppelten Entkopplung (englisch: double-decoupling) zu erfassen, die zentrales Thema der Thematischen Strategie zur nachhaltigen Nutzung natürlicher Ressourcen ist.

Der Workshop brachte Experten und Repräsentanten von Datennutzern, Datenanbieter aus der Forschung und Statistische Ämter zusammen. Verschiedene Ansätze und Positionen wurden hervorgehoben und hinsichtlich grundlegender methodischer Fragestellungen und Interpretierbarkeit der abgeleiteten Indikatoren diskutiert. Eine „*mind-map*“ Übung arbeitete grundlegende Anforderungen an einen idealen Indikator für Ressourcennutzung aus der Sicht von Anwendern, Anbietern oder Statistikern heraus. Eine interaktive Einheit über Anforderungen für das offizielle Berichtssystem in Deutschland und seinen Verbesserungsbedarf richtete das Hauptaugenmerk weiter-

führend auf das Interesse der Bundesregierung, wie mit der Erfassung von Ressourcennutzung und Ressourcenproduktivität weiter umgegangen werden sollte.

Unter den Nutzern von Daten und Indikatoren war die allgemeine Tendenz, RME im ersten Schritt zu entwickeln und im Folgenden TMR/TMC welche als umfassendste Indikatoren angesehen wurden. Auch Wirkungsbezogene Indikatoren erhielten die Aufmerksamkeit der Anwender. Es gab jedoch keine eindeutige Haltung, den gegenwärtigen Leitindikator kurzfristig zu ersetzen.

Datenanbieter aus der Forschung unterstützten ihren jeweiligen Schwerpunkt der Indikatorenentwicklung, mit einer generellen Tendenz – wie bei den Anwendern – zunächst den RME zu entwickeln und in der Folge TMR/TMC, indem einer modularen Vorgehensweise zu folgen wäre wonach die nicht genutzte Extraktion zum RME hinzugefügt wird, während man weiterer Forschung zu wirkungsbezogenen Indikatoren offen gegenüber stünde.

Statistiker favorisierten RME und zeigten Interesse sowohl für TMR/TMC als auch für die wirkungsbezogenen Indikatoren für Ressourcennutzung.

Darüber hinaus wurden einige kritische offene Fragestellungen zur konzeptionellen Fundierung der verschiedenen Indikatoren identifiziert, die weiterer Diskussion und Harmonisierung bedürfen.

Executive Summary

The German government intended to assess the applicability of macro indicators measuring the use of resources by the German economy and requested suggestions for further use and development. In a broader context, this relates to the development of a national programme for sustainable resource management, which is, for instance, requested by the EU´s Thematic Strategy for Sustainable Use of Natural Resources. More specifically, the existing monitoring of progress towards sustainability in pursuit of the national strategy for sustainable development should be improved, through widening the scope of the raw material productivity indicator used so far.

The material flow accounting concepts of ESTAT and OECD provide a stepwise extension of indicators for resource use and resource productivity. Direct Material Input (DMI) and Domestic Material Consumption (DMC) build the basis; however, they do not account for indirect flows of imports and exports, nor consider unused extraction, thus missing the foreign dimension and the full extent of primary resource extraction. DMI and DMC can be accounted as raw material equivalents (RME) that accounts for indirect flows of used extraction thus leaving out unused extraction. The most comprehensive indicators accounting for the total global primary material requirements for production and consumption, i.e. including both used and unused extraction, account for Total Material Requirement (TMR) and Total Material Consumption (TMC).

Furthermore, the European Commission aims at developing indicators to account for environmental impacts associated with resource use, so as to be able to monitor progress towards double-decoupling which is a central issue in the Thematic Strategy on the Sustainable Use of Natural Resources.

The workshop brought experts and representatives of data users, data providers from research, and statistical offices together. Different approaches and positions were highlighted and discussed regarding basic methodological issues and interpretability of derived indicators. A mind map exercise worked out basic requirements of an ideal resource use indicator as seen by users, providers or statisticians. An interactive session on requirements for German official reporting and need for improvement put the focus further on the interest of the German government how to proceed with monitoring resource use and resource productivity.

Among the users of data and indicators there was a general tendency to go for RME first and then for TMR/TMC which was regarded as most comprehensive indicator. Also impact related indicators received some attention of users. However, there was no clear attitude towards changing the current headline indicator in the short term.

Providers from research institutes confirmed their background for indicators work, with a general tendency – like users - to go for RME in the short term and for TMR/TMC in the longer run by following a modular approach and add up unused extraction to RME, while being open towards further research on resource use impact indicators.

Statisticians were in favour of the RME indicator and showed interest for TMR/TMC as well as for an impact related resource use indicator.

Apart from that, some critical open issues concerning the conceptual foundation of the different indicators were identified which require further discussion and harmonisation.

Introduction

In view of increasing production for domestic consumption and export, and growing international trade interlinkages, the question arises whether the official German indicator for (abiotic) raw material consumption were still a useful measure for monitoring development by sustainable policy. Since 2001 this indicator is used as denominator for the headline indicator “resource productivity” of the German sustainability strategy, expressed by GDP/abiotic raw material consumption, meant to indicate decoupling of resource use from economic development. Reliable and unambiguously interpretable measures for raw material consumption are essential in view of the necessity to employ monitoring instruments for sustainable resource management programs operationalising the EU’s thematic strategy for the sustainable use of natural resources.

In the context of the MaRess project, an international workshop on „Material Use Indicators for Measuring Resource Productivity and Environmental Impacts“ with national and international participants from statistical offices, research institutes and official government institutions took place on 25-26 February 2010 in Berlin. The 2-days workshop facilitated intensive exchange of ideas about the meaningfulness and suitability of macro indicators for resource use derived from Material Flow Accounting (MFA), preparing the floor for evaluation by the participants which indicators would be most suitable for further development. Background information was provided with brief descriptions of the most prominent resource use indicators including their conceptual and methodological basis, applications in national and international context and statistical strengths and weaknesses. The MFA indicators that were discussed were Direct Material Input (DMI), Domestic Material Consumption (DMC), Total Material Requirement (TMR), Total Material Consumption (TMC), DMI and DMC in terms of RME , i.e. raw material equivalents, as well as the environmentally weighted material consumption indicators EMC (CML, Leiden University) and EVIL (IFEU Heidelberg).

The discussion was oriented towards the main questions: „Main criteria: Do the underlying concepts and theoretical foundations ensure direction safety with regard to progress towards sustainable resource use, with regard to generic or specific environmental impacts? Secondary criteria: Is practicability given with regard to data availability, effort for compilation and regular up-date, robustness of data, considering accuracy and uncertainties? Is international comparability given and/or can harmonisation be developed?”

The first day of the workshop was dedicated to presentations and discussions about the suitability of macro level raw material consumption indicators, the second day was focusing on the methodological approach to account for environmental impacts of resource use. A half-day mind-map exercise with the participants grouped after statisticians (S), data users (U) and data providers (P) aimed at summarizing the preferences and needs of these groups for evaluation and further development of the monitoring instruments.

1 Overview

The following section provides an overview of the presentations, interactive processes and discussions during the workshop which were centred at indicators for resource use and environmental impacts aiming at analysing their potentials and requirements for further development. The main criteria and questions were:

Main criterion:

- Do the underlying concepts and theoretical foundations ensure direction safety
  - with regard to progress towards sustainable resource use
  - with regard to generic or specific environmental impacts?

Secondary criteria:

- Is practicability given with regard to
  - data availability
  - effort for compilation and regular up-date
  - robustness of data, considering accuracy and uncertainties
- Is the methodological basis solidly described, and practical guidance available?
- Is international comparability given and/or can harmonisation be developed?

The candidate indicators will have to be assessed against these criteria.

1.1 Resource Use Indicator - Mind-mapping

The mind mapping exercise was moderated by Dr Bringezu/WI around the central question what "The ideal resource use indicator should…". Participants of the work-shop formulated their ideas. They then received 5 stickers each, the colours allowing to distinguish data users (U), data providers (P), and statistical offices (S)[1]. The repre-sented institutions were assigned as follows:

U: Environment Agency (UBA); Ministry for Environment (BMU); European Envi-ronment Agency (EEA); Intecus GmbH

P: University Leiden (CML); European Topic Centre Sustainable Consumption and Production (ETC-SCP); Institute for Energy and Environment (IFEU); National Institute Japan for Environmental Studies (NIES); Sustainable Europe Institute (SERI); Wupper-tal Institute (WI)

S: German Federal Statistical Office (Destatis); Statistical Office of the European Union (Eurostat)

Tab. 1 provides an overview of the results from the mind-mapping.

Results from the exercise show that the statistical offices set high standards for quality in concept, method and data while being easily communicable to target audience. Providers and users supported the need for high quality standards and ease to communicate. Their main concern however was on the issue of problem shifting in its characteristics across countries, across material, across impacts. Providers and users further expressed their preference to indicate total material needs which is a prerequisite for meaningful indication of problem shifting. This goes along with policy relevance for practise. Applicability at different scales (macro-meso-micro) was in particularly supported by users.

In more detail, the results from the mind map can be grouped as follows (in brackets: number of stickers for providers/users/statisticians):

- high priority was given by providers and users for the ideal indicator to be robust against problem shifting (6/9/-);
- providers and users (5/5/-) saw a requirement to indicate Total Material Need for domestic production and consumption;
- strong support from user side also for the indicator to be applicable at different scales (2/6/-);
- as well as for policy relevance for practice (3/6/-);
- support by all 3 groups found the issues: be measurable on regular basis/statistical quality standards (2/5/3), be simple to understand (2/2/3), and be analytically sound enough and transparent (3/5/3);
- less value was given to some issues with intermediate scores, like addressing secondary material use implications(-/4/-), capturing full life-cycle impacts (2/2/-), can be aggregated across countries (1/2/-), linked to aims and targets (1/1/1), linking environment and economy at detailed level (3/-/1), consider also land use, water, energy, ecosystem services (2/1/1), be timely and cost efficient (-/1/2).
- other issues on the board received less or no attention for priority setting. For instance, the issue of including both stocks and flows in use which is rather part of the SEEA concept but can hardly be operationalised towards a resource use indicator.

[1] Altogether, providers used 35 stickers on the board, users 50 stickers, and statisticians 15 stickers.

Tab. 1: Mind-mapping results – ranking by total points

The ideal resource use indicator should:	**Points**				**Rank**		
	U	**P**	**S**	**TOTAL**	**U**	**P**	**S**
be robust against problem shifting - across countries, across time, across material, across impacts	9	6		15	1	1	
be analytically sound enough; transparent; uncertainties should be calculable	5	3	3	11	4	3	1
show Total Material Need for domestic production and consumption	5	5		10	4	2	
be measurable on regular basis (also in developing and transition countries)/statistical quality standards	5	2	3	10	4	6	1
be policy relevant for practice	6	3		9	2	3	
be applicable at different scales (macro-meso-micro); sectors; product groups	6	2		8	2	6	
be understandable for laypersons and politicians / sufficiently simple	2	2	3	7	8	6	1
reflect secondary material use implications in broader context	4			4	7		
capture full life-cycle impacts incl. translocated and hidden problems	2	2		4	8	6	
be linking environment and economy at detailed level		3	1	4		3	5
consist of a bundle to consider also land use, water, energy, ecosystem services	1	2	1	4	11	6	5
be able to aggregate across countries	2	1		3	8	12	
be linked to aims and targets	1	1	1	3	11	12	5
be timely, cost efficient	1		2	3	11		4
be complemented by driver and response indicator and impact indicator		2		2		6	
represent use of nature as factor input to production and consumption			1	1			5
correlate with general environmental impact of production and consumption; scarcity	1			1	11		
be attributable to both producers and consumers		1		1		12	
reflect societal shift from materials to non-monetary value based				0			
Include flows and stocks in use				0			
adress renewability				0			
be basis for further calculations				0			
be sensitive to improvement options				0			
TOTAL	**50**	**35**	**15**	**100**			

Note: total points were used for overall ranking purpose only. Preferences of the three distinct groups may be taken from the three ranking columns for U, P, and S in the last three columns on the right side.

1.2 Assessment of indicators

A session on the second day of the workshop was to reflect on participants input and the discussion moderated by Mr. Bringezu/WI aimed at systematically assessing the indicator concepts with critical characteristics. Participants of the workshop received 10 Stickers each, colours again distinguishing data providers (P), data users (U) and statistical offices (S)[2]. Indicators addressed by this assessment have been described and analysed in detail in the background paper in advance of the workshop (Annex 1).

One side of Tab. 2 was dedicated to the evaluation of the indicators in terms of what German official reporting should go for.

In essence, users clearly indicated the demand to monitor TMR/TMC, while regarding RME as more feasible for the moment; this was corroborated by data providers suggesting RME rather than TMR/TMC as next step. Statisticians currently aim at RME. On the other hand, statisticians see also a need to further explore RME as well as TMR/TMC. The resource use impact indicators are rather a case for further exploration and development as supported more or less by all three groups. The shortcomings of DMI/DMC became obvious in that only providers proposed to aim at their use (e.g. as rather simple, proven and readily available indicators, compared to RME and TMR/TMC).

In more detail, the results are:

- providers were in favour of aiming at DMI/DMC as well as TMR/TMC, while users voted for TMR/TMC, and statisticians aimed at RME only;
- providers and users saw RME in first place to take as the next step - possibly interim to the more distant aim -, while statisticians put two score points to DMI/DMC and one to other resource use impact indicator;
- statisticians rather saw the need to explore TMR/TMC, but also RME and the other resource use impact indicator, while users and providers saw particular need to explore the three resource use impact indicators, and users further voted to explore RME and TMR/TMC.

2 Altogether, providers used 77 stickers on the board, users 80 stickers, and statisticians 30 stickers.

Tab. 2: Requirements for German official reporting – experts judgements

German official reporting should:		**aim to use**				**use as next step**				**explore**			
		U	**P**	**S**	**TOTAL**	**U**	**P**	**S**	**TOTAL**	**U**	**P**	**S**	**TOTAL**
DMI/DMC	DMI		2		2			2	2				0
	DMI/DMC				0				0				0
	DMC		3		3				0				0
	TOTAL	0	5	0	5	0	0	2	2	0	0	0	0
RME	RME-DMI			3	3	3	4		7				0
	RME	1	1		2	2			2	2		2	4
	RME-DMC		1	3	4	2	3		5				0
	TOTAL	1	2	6	9	7	7	0	14	2	0	2	4
TMR/TMC	TMR	3	1		4		1		1				0
	TMR/TMC		2		2		1		1	3	1	3	7
	TMC	2	1		3		1		1				0
	TOTAL	5	4	0	9	0	3	0	3	3	1	3	7
EMC			1		1				0	5	3		8
EVIL					0				0	1	4		5
Other resource use impact indicator					0			1	1	3	2	2	7
TOTAL		**6**	**12**	**6**	**24**	**7**	**10**	**3**	**20**	**14**	**10**	**7**	**31**

Another side of Tab. 3 was dedicated to the need for indicators improvement.

To sum up, need for both method and data improvements were seen by all participants especially for RME and TMR/TMC. While improvement requirements for the resource use impact indicators was focused by providers and users on the method aspects.

In more detail, the results are:

- for the national (German) level, need for method specification was seen by providers in particular for RME, EMC, and EVIL, while users put strong emphasis on RME, and statisticians gave one score point each to TMR/TMC, EVIL and another impact indicator;
- national data development needs were clearly focused on RME and TMR/TMC by all three groups;
- providers obviously put more emphasis on international/EU harmonisation of methods than at national level and in particular for RME and TMR/TMC as well as for EMC. Users again put strong emphasis at RME method harmonisation at interna-

tional level and less emphasis for EMC and TMR/TMC. Statisticians were less interested in international method harmonisation and gave only two score points to RME and one to the other impact indicator;

- providers saw high need for data improvement at international level in particular for RME and to lesser extent for TMR/TMC and EMC. Also users found high data needs for these three indicators though with rather equal votes for RME and TMR/TMC. Statisticians saw international data improvement as well for RME and TMR/TMC.

Tab. 3: Need for improvement – experts judgements

Indicators need improvement:		**Nationally / Germany**								**EU / Internationally**							
		Method specification				**Data**				**Method harmonisation**				**Data**			
		U	**P**	**S**	**TOTAL**	**U**	**P**	**S**	**TOTAL**	**U**	**P**	**S**	**TOTAL**	**U**	**P**	**S**	**TOTAL**
DMI/DMC	DMI				0				0				0				0
	DMI/DMC				0				0				0				0
	DMC				0				0				0				0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RME	RME-DMI	1			1	1			1	2	1		3	1	1		2
	RME	5	2		7	4	2	2	8	5	4	2	11	4	5	2	11
	RME-DMC	1			1	1	1		2	2	2		4	1	2		3
	TOTAL	7	2	0	9	6	3	2	11	9	7	2	18	6	8	2	16
TMR/TMC	TMR	1			1	1			1		1		1		1		1
	TMR/TMC	1	1	1	3	2	1	2	5	2	2		4	6	2	2	10
	TMC				0				0		1		1				0
	TOTAL	2	1	1	4	3	1	2	6	2	4	0	6	6	3	2	11
EMC			3		3		1		1	3	4		7	3	3		6
EVIL			2	1	3				0		2		2				0
Other resource use impact indicator		2		1	3	2			2		1	1	2	2			2
TOTAL		**11**	**8**	**3**	**22**	**11**	**5**	**4**	**20**	**14**	**18**	**3**	**35**	**17**	**14**	**4**	**35**

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1.3 Essentials of the presentations

The presentations given during the workshop are found in annex 4. They are listed and shortly described in the following.

1.3.1 Introduction to the topic – overview and target questions of the workshop (S. Bringezu, WI, Germany)

The presentation of Dr. Bringezu introduced to the issue of resource use and resource productivity with a view on the raw material productivity indicator of the German sustainability strategy. The presentation was structured as follows:

- Why measure resource productivity?
- Some global trends
- Environmental policy and the German Sustainable Development Strategy (SDS)
- Improving the raw material productivity indicator
- Issues for discussion

The following issues prepared the ground for discussions and interactive exercises for indicators assessment during the workshop:

- Direction safety
  (a) progress towards sustainable resource use
  (b) regarding generic or specific environmental impacts
- Practicability
  (a) data availability
  (b) effort for compilation and regular up-date
  (c) robustness: accuracy and uncertainties
- Solid method description, available guidance
- International comparability and harmonization

1.3.2 The OECD framework of accounting for material flows and resource productivity and recent experiences in Japan (Y. Moriguchi, NIES, Japan)

The contents of the speech of Dr. Moriguchi were:

- Background: Massive material flows of industrialized economies
- Progress in Material Flow Analysis/Accounting/Indicators
  - Interaction between international activities and nation-specific progress

  - Interaction between methodological experts and policy users
  - Progress in expert communities, e.g. ConAccount, ISIE
- OECD's activities on material flows and resource productivity
  - Council Recommendations (1st CR on MF/RP 2004, 2nd CR on RP 2008)
  - OECD's set of guidance documents
  - Co-operations with other int'l organizations (EEA, EUROSTAT, UNEP)
- Recent experiences in Japan
  - Introduction of of macro MF indicators and numerical targets in Japanese
  - 1st Fundamental Plan for establishing a Sound Material-Cycle Society
  - New MF indicators with/without numerical targets in revised 2nd FPSMCS
  - Use of MF approach in industries (e.g. in environmental reporting)
- Conclusion

With regard to the workshop focus, Dr. Moriguchi posed key methodological questions to meet policy needs:

- Attribution of MFs to national production or consumption to ensure international comparability of MF indicators
- Disaggregation by sectors and by materials to meet the needs from other users than national policy makers
- Quantification of hidden flows (system boundary, data availability)
- Linking MF information with specific environmental problems (impact, damage-based quantification)
- Better understanding of upstream (e.g. mining) and downstream (e.g. waste management) flows and their environmental impacts
- Compilation of internationally comparable/common database

1.3.3 Measuring material use and resource productivity in Europe (S. Moll, Eurostat)

Mr Moll was giving an overview of major developments at Eurostat with regard to material flows and resource productivity indicators, in particular methodological harmonisation and data generation via the bi-annual Eurostat ew-MFA Questionnaire launched in 2007 and 2009 so far. He further pointed out envisaged future developments at Eurostat which will focus on developing the raw material equivalents and investigate further into the area of environmental impacts of resource use.

1.3.4 Measuring DMI, DMC, TMR and TMC of Germany (H. Schütz, WI, Germany)

Dr. Schütz (with co-author Mathieu Saurat/WI) provided insight into the work at WI on material flow indicators for Germany which had been part of a project for UBA (Schütz and Bringezu 2008) with new results added for sensitivity analysis of the accounts for indirect flows. The presentation was structured as follows:

- Definition, Objectives, Foundations
- Practical application
- Some old and some new results
- Policy relevance
- Development requirements and perspectives

The speaker pointed out ongoing development at Eurostat, OECD and UN to harmonise material flow accounts with the SEEA/SNA. For the issue of indirect material flows of imports and exports, most promising initiatives will likely combine the coefficients approach with input-output analysis from a multi-regional IO-MFA model (Giljum et al. 2008).

1.3.5 DMI and DMC of Germany calculated as Raw Material Equivalents (S. Buyny, Destatis, Germany)

The presentation of Ms Buyny was structured as follows:

- What? Why? and How?
- Results
- Evaluation and improvement potential

Ms Buyny gave insight into the development of the RME indicator at Statistics Germany in cooperation with IFEU and presented first results for Germany in comparison with the former raw material productivity indicator of the sustainability strategy.

1.3.6 Accounting for impacts of resource use – outline of a challenge and recent approaches (S. Bringezu, WI, Germany)

The presentation of Dr. Bringezu introduced to the issue of accounting for impacts of resource use with a view on major challenges and insights from recent and ongoing work. The presentation was structured as follows:

- The goal of double de-coupling
- Basic challenges of impact assessment

  - System definition
  - Characterisation and quantification of impacts
  - Normalization and weighting of single impacts
  - Weighting between different impacts
- Conclusions:
  - Single impacts of overall resource use (production & consumption) such as GWP can be accounted with reliable certainty
  - Accounting for various other specific impacts still difficult:
    1. characterization of important LCA impact categories still lacking or based on disputable assumptions
    2. aggregation to single indexes requires additional normative assumptions
  - Macro approaches in combination with reliable LCA elements seem promising to derive key indicators such as global land use (e.g. GLUA) and related change

1.3.7 The Environmentally weighted Material Consumption – EMC (E. Van der Voet, CML, Netherlands)

Dr. van der Voet gave an overview of the development of the EMC indicator under the aim to account for environmental impacts of resource use with regard to the EC Thematic Strategy on the sustainable use of natural resources (van der Voet et al. 2005, 2009). Dr. van der Voet pointed out the use of the EMC indicator:

- Developed to measure, combined with GDP and DMC, double decoupling
- Based in active research fields: MFA and LCA
- Can be used at aggregate level as decoupling indicator
- Also can be used at disaggregate level
  - broken down into materials
  - broken down into impact categories
- Further development
  - material balances: agreement on data and procedures (Eurostat)
  - impact factors: agreement on which ones to use (JRC)
  - aggregation: agreement on weighting scheme (JRC)

1.3.8 Correlations of mass flow based indicators with environmental impacts (J. Giegrich, IFEU, Germany)

The presentation has not been provided for inclusion until 25 October 2010.

1.4 Final statements of participants

A final round was held with statements of all participants on their conclusion from the workshop as regards the most appropriate set of measures for resource use and productivity and recommendations for further development in particular for the German strategy on sustainable development and its raw material productivity.

Some of the major outcomes are:

- Statisticians were in favour of the RME indicator and show interest for an impact related resource use indicator as well as TMR/TMC, where they see clarification needs for the inclusion of unused material extraction;
- Among the users of data and indicators there was an overall tendency to go for RME at first and for TMR/TMC in the long run which was regarded as most comprehensive indicator. Also impact related indicators received some attention of users. However, there was no clear attitude towards changing the current headline indicator in the short term. Some individual statements by users were opening other aspects of the issue, in particular to have a look also at the GDP part of the resource productivity indicator, to have indicators also for the sector level, to reflect absolute resource use as well and not only productivity, and to consider resource intensity of trade;
- Providers in principle confirmed their background for indicators work, with a general tendency – like users - to go for RME in the short term and for TMR/TMC in the longer run by following a modular approach and add up unused extraction to RME, while being open towards further research on resource use impact indicators.

1.5 Open issues

During the workshop some issues critical for the conceptual foundation and interpretation of the resource indicators were discussed, in particular the issue of how to treat secondary material (scrap or waste) which arose from the presentation of Ms Buyny on the RME indicator.

Accounting for secondary material, scrap, waste etc.

Secondary material is part of material flows both for domestic production and through imported and exported goods where it may be a commodity on its own (e.g. waste and scrap of alloy steel) or embodied in material where the amount of secondary share is usually unknown (e.g. flat-rolled products of steel).

Material use indicators like DMI and DMC do include imported and exported secondary materials (Eurostat ew-MFA questionnaire 2009 tables), but exclude secondary materials from domestic production (the domestic account in ew-MFA considers raw materials only). When accounting for the indirect material flows of imported and exported secondary materials, only the primary materials required to provide these are counted. This is in line with the MIPS concept.

The indicator Raw Material Equivalents (RME) as it is derived by Destatis does include secondary material for imports but not for domestic production (with the argument to avoid double counting, because the RME for domestic production had already been counted in a previous period).

In contrast to the account for indirect material flows (as for TMR and TMC), the currently practised RME accounts treats imported secondary material as if it were produced from primary material. As a consequence, that indicator sums up real and virtual (de facto avoided) flows.

The basic issues to be clarified for a future material use indicator of the economy thus are:

- in which way should secondary material be considered in domestic accounts? And
- should imported (and exported) secondary material be accounted for? And - if yes -
- should indirect material requirements be accounted – and possibly in which way?

Answering these questions will probably depend on the overall target question(s) to be answered by the indicators. As indicators are limited in scope, also separate accounts on recycling flows could be an option.

The definite clarification of these issues is crucial for the interpretation and international harmonisation of material use indicators. There was no final consensus reached during the workshop. So the issue remains open for further discussion and requires clarification.

2 Outlook and next steps

When deciding on the extension of the raw material productivity indicator, the German government might reflect on the questions to be primarily answered by the indicators. The results of the workshop which worked out the main features of the different resource use indicators may then help to select the appropriate candidates.

In any case, there is a need for developing an international data base for resource use coefficients of internationally traded products in order to support national statistical offices to account for indirect resource flows (Giljum et al. 2008). A pilot data base should be developed in cooperation with an appropriate host institution. This requires further support.

With reference to the needs for improvement of the indicators it is proposed to involve national or international task forces for clarification of methodological questions like how to treat secondary materials. The Eurostat task force on ew-MFA would be a candidate in this respect.

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Nomenclature

Abbreviation	Explanation
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)
CML	Institute of Environmental Sciences, Leiden University, The Netherlands
ConAccount	concerted action titled "Coordination of Regional and National Material Flow Accounting for Environmental Sustainability"
CR	Council Recommendation (OECD)
Destatis	Federal Statistical Office (Germany)
DMC	Domestic Material Consumption
DMI	Direct Material Input
EC	European Commission
EEA	European Environment Agency
ETC-SCP	European Topic Centre – Sustainable Consumption and Production
EMC	Environmentally weighted Material Consumption
ESTAT	Eurostat – Statistical Office of the European Union
EU	European Union
EVIL	Environmental Impact Load
ew-MFA	economy-wide Material Flow Accounting
FPSMCS	Fundamental Plan for establishing a Sound Material-Cycle Society (Japan)
GDP	Gross Domestic Product
GLUA	Global Land Use Agriculture
GWP	Global Warming Potential
IFEU	Institute for Energy and Environmental Research, Heidelberg/Germany
IO	Input-Output
ISIE	International Society for Industrial Ecology
JRC	Joint Research Centre

LCA	Life Cycle Analysis
MF	Material Flows
MFA	Material Flow Analysis
MIPS	Material Input Per Service unit
NIES	National Institute for Environmental Studies (Japan)
OECD	Organisation for Economic Co-operation and Development
RME	Raw Material Equivalent
RP	Resource Productivity
SDS	Sustainable Development Strategy
SEEA	System of Integrated Environmental and Economic Accounting
SERI	Sustainable Europe Research Institute. Vienna/Austria
SNA	System of National Accounts
TMC	Total Material Consumption
TMR	Total Material Requirement
UBA	Federal Environment Agency (Germany)
UN	United Nations
UNEP	United Nations Environment Programme
WI	Wuppertal Institute for Climate, Environment and Energy, Wuppertal/Germany

Annexes

Annex 1: Agenda of the workshop

Annex 2: Official invitation

Annex 3: Participants list

Annex 4: Presentations

Annex 1:
Agenda of the workshop

Material Use Indicators for Measuring Resource Productivity and Environmental Impacts

Workshop organized by Wuppertal Institute and Federal Environment Agency (UBA)

Berlin, 25.-26.2.2010

Venue: Presse- und Besucherzentrum der Bundesregierung, Reichstagufer 14, 10117 Berlin, Room 4

Agenda - as of 22 Feb 2010

25 February

12:30 - 13:00 Registration

13:00 - 13:10 Welcome by Harry Lehmann, UBA

13:10 - 13:30 Introduction to topic - overview and target questions of the workshop
Stefan Bringezu, Wuppertal Institute

13:30 -14:00 The OECD framework of accouting for material flows and resource productivity and recent experiences in Japan
Yuichi Moriguchi, NIES, Japan

14:00 – 14:30 Measuring material use and resource productivity in Europe
Stephan Moll, Eurostat

Coffee break: 14:30 - 15:00

15:00 - 15:30 Measuring DMI, DMC, TMR and TMC of Germany
Helmut Schütz, Wuppertal Institute

15:30 - 16:00 DMI and DMC of Germany calculated as Raw Material Equivalents
Sarka Buyny, DESTATIS

16:00 - 16:30 Questions for clarification and discussion

Coffe Break 16:30 - 17:00

17:00 - 18:00 Mind map exercise and discussion: Important characteristics of a national resource use indicator
Moderation: Stefan Bringezu

19:30 Dinner

Wuppertal Institute for Climate, Environment and Energy

Umwelt Bundes Amt for our Environment

26 February

9:00-9:30	Accounting for impacts of resource use - outline of a challenge and recent approaches Stefan Bringezu
9:30-10:00	The Environmentally weighted Material Consumption - EMC Ester van der Voet, CML, Netherlands
10:00-10:30	Correlations of mass flow based indicators with environmental impacts Jürgen Giegrich, Ifeu, Germany
10:30-11:00	Discussion
11:00-11:30	Coffee break
11:30-12:30	Assessing the indicator concepts with critical characteristics - a joint undertaking Moderation: Stefan Bringezu
12:30-13:00	Wrap up and final round

Close: 13:00

Annex 2:
Official invitation

Wuppertal Institut
für Klima, Umwelt, Energie
GmbH

Wuppertal Institut • Postfach 100480 • 42004 Wuppertal

- Invitees list -

Wuppertal Institute for
Climate, Environment
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Vizepräsident und kommissarischer wissenschaftlicher Leiter
Prof. Dr. Manfred Fischedick

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Datum 11. Feb. 2010

Invitation Workshop
Material Use Indicators for Measuring Resource Productivity and Environmental Impacts, Berlin, 25-26 Feb 2010

Dear colleagues

On behalf of the German Federal Environment Agency (UBA) we invite you to participate in the announced workshop.

The German government intends to assess the applicability of macro indicators measuring the use of resources by the German economy and requests suggestions for further use and development. In a broader context, this relates to the development of a national programme for sustainable resource management, which is, for instance, requested by the EU´s Thematic Strategy for Sustainable Use of Natural Resources. More specifically, the existing monitoring of progress towards sustainability in pursuit of the national strategy for sustainable development shall be improved, through widening the scope of the raw material productivity indicator used so far.

The agenda is attached, including the venue.

The draft list of participants is also enclosed. Those of you who did not already confirm participation are kindly asked to do so (mail to mary.walker@wupperinst.org).

If you still need a hotel you may get a special price at the Park Inn Berlin-Alexanderplatz (reservations.berlin@rezidorparkinn.com). when you refer to code "Bundrate".

We will provide you with a background document one week before the workshop.

The presenters are kindly requested to mail (1) an abstract (no more than 150 words), and (2) the ppt until the 18th Feb.

Best regards

Dr. Stefan Bringezu
Director
Research Group
Material Flows and Resource Management

Enclosed:
- Agenda, incl. venue
- Draft participants list

Annex 3:
Participants list

List of participants

Workshop on Material Use Indicators for Measuring Resource Productivity and Environmental Impacts

25. – 26. Februar 2010

Presse- und Besucherzentrum der Bundesregierung, Reichstagufer 14, 10117 Berlin, Room 4

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33	Malte Hentschke (Einlass)	Wuppertal Insitut	Berlin		

Annex 4:
Presentations

Material Use Indicators for Measuring Resource Productivity and Environmental Impacts

Introduction to the Workshop

Dr. Stefan Bringezu

Member of the International Panel for Sustainable Resource Management

Director
Material Flows and Resource Management
Wuppertal Institute

Presentation
25 Feb 2010
Berlin

The presentation

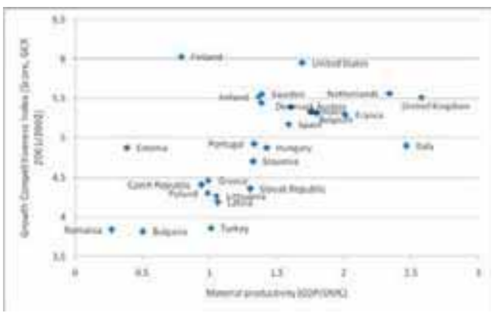
- **Why measure resource productivity?**
- **Some global trends**
- **Environmental policy and the German SDS**
- **Improving the raw material productivity indicator**
- **Issues for discussion**

The presentation

- **Why measure resource productivity?**
- Some global trends
- Environmental policy and the German SDS
- Improving the raw material productivity indicator
- Issues for discussion

Why measure and increase resource productivity?
- not only a matter of environmental concern -

- **Decoupling environmental pressure from economic growth**
- **Supply security and reduction of import dependance**
- **Driver of innovation, potentials for cost reductions in industry, risk of unemployment grows with low RP**
- **International competitiveness grows with material productivity**
- **Fair international burden sharing – reduced risk of problem shifting**



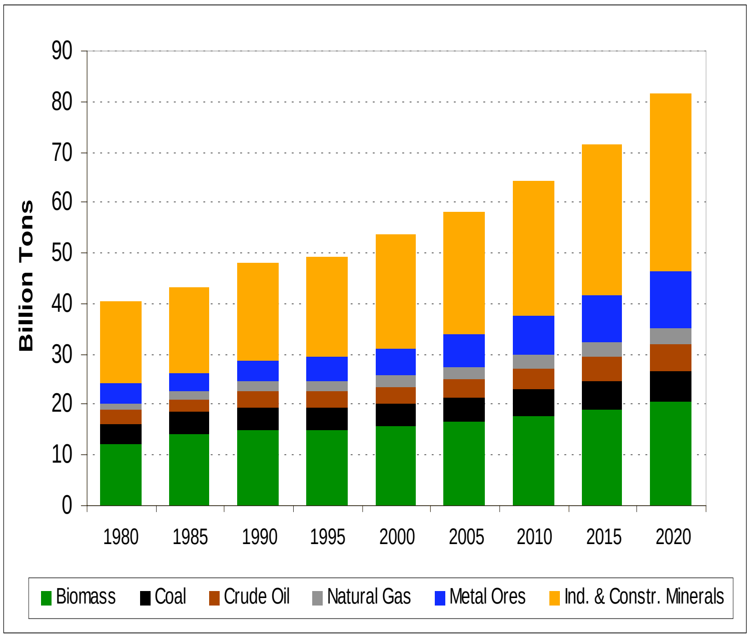
The presentation

- Why measure resource productivity?
- **Some global trends**
- Environmental policy and the German SDS
- Improving the raw material productivity indicator
- Issues for discussion

Growing global resource use

- **Projected increase of used extraction from 2000 to 2020: 1,5 times**
- **Unused extraction adds at least the same amount***

MOSUS Baseline scenario DEU



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Source: SERI; Giljum et al. 2007

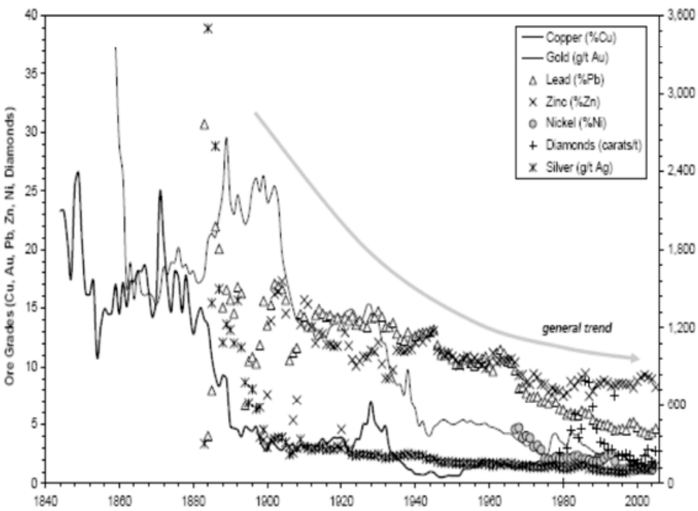
Global resource extraction expected to increase
Some estimates

- **Global resource extraction in 2000: 145 – 180 bill. tonnes**
  - fossil fuels, metals, other minerals, biomass (used + unused): 80 bill. t
  - earth excavation: 40 – 50 bill. t
  - erosion in agriculture: 25 – 50 bill. t
- **Total Material Consumption (TMC) of the EU in 2000: 44 t/cap**
  global adoption in 2050 (9 bill people) -> 400 bill. t (factor 2-3)
- **TMC of USA in 1991: 74 t/cap**
  global adoption in 2050 -> 666 bill. t (factor 4-5)

-> **Global adoption of current EU and/or US technologies and consumption patterns could lead to increase by factor 2 to 5**

Source: Bringezu et al. 2009

"New Scarcity": growing implications of resource use

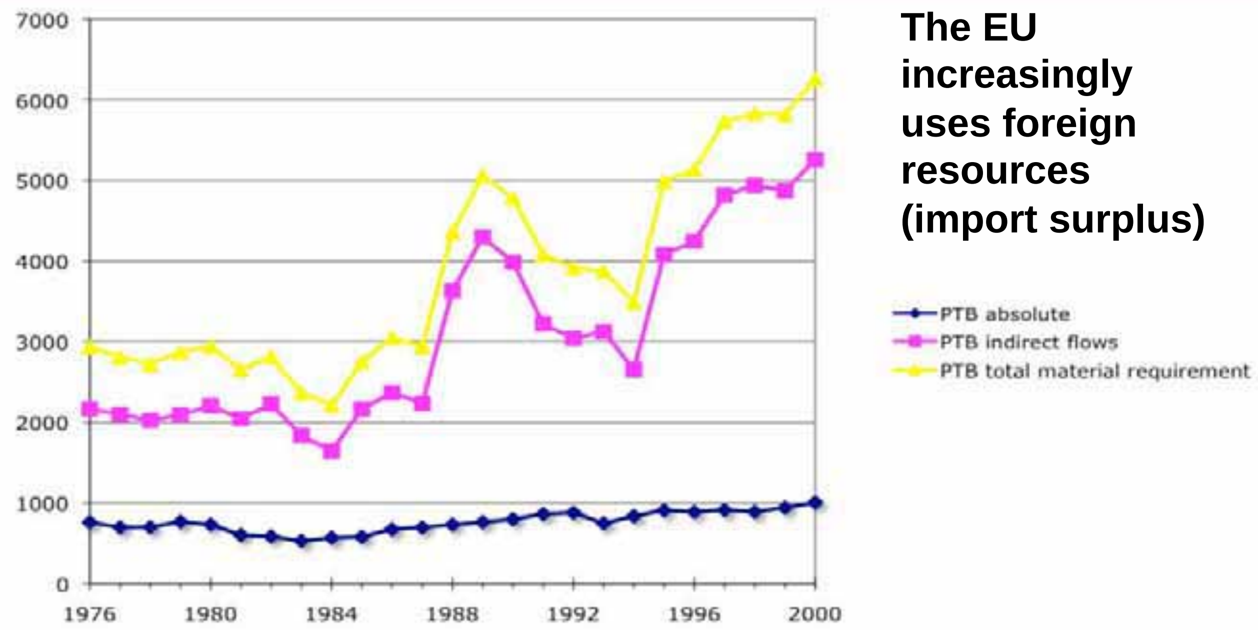


Source: Mudd 2007, Australia

Foto Edgar Llamoca

- **Ore grades decline**
  -> impacts of mining grow
  (waste, water, landscapes)

Physical trade balance of EC/EU considering hidden flows



The EU increasingly uses foreign resources (import surplus)

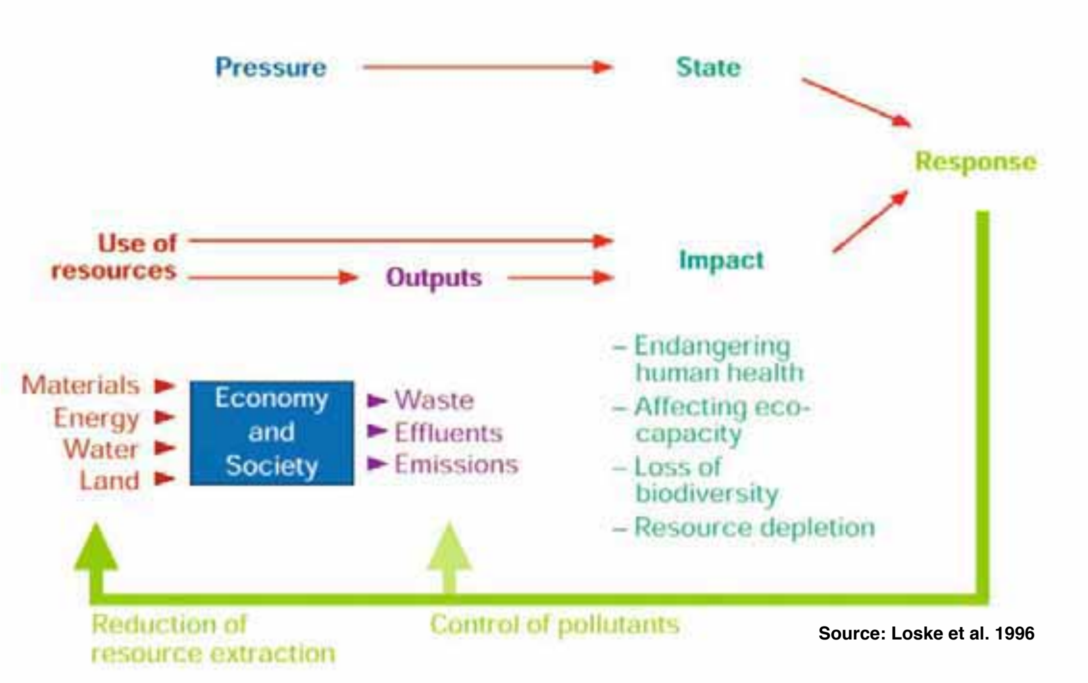
1976: EC-9; 1981: + Greece; 1986: + Spain, Portugal; 1995: + Austria, Finland, Sweden
1991: re-united Germany

Source: Bringezu et al. 2009, based on Schütz et al (2003)

The presentation

- Why measure resource productivity?
- Some global trends
- **Environmental policy and the German SDS**
- Improving the raw material productivity indicator
- Issues for discussion

Background: Development of environmental policy



Source: Loske et al. 1996

The German Sustainability Strategy (established 2002)

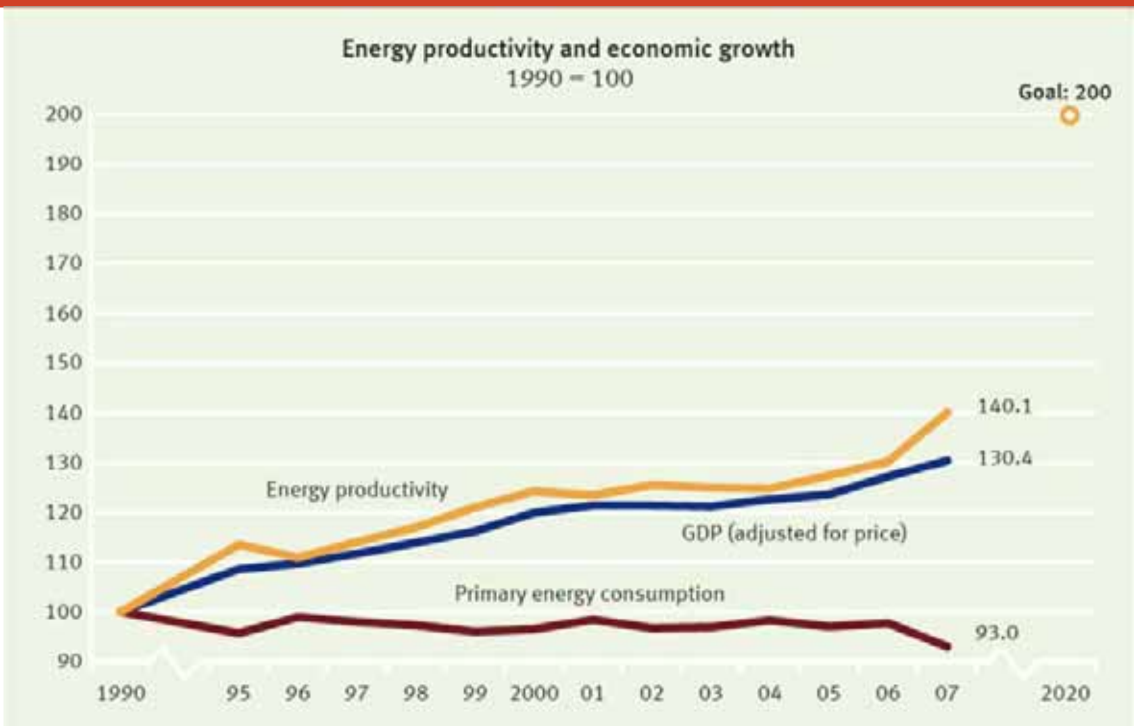
- **7 Environmental indicators (out of 21)**
  - GHG emissions
  - share of renewable energies
  - growth of settlement and infrastructure land use
  - species diversity and quality of landscape
  - nitrogen surplus
  - share of organic farming
  - air pollution
- **Scope mainly national**
  - Indirect GHG emissions of imports/exports are also reported

The German Sustainability Strategy
aiming at decoupling

- **No1 indicator:**
  - **1a energy productivity (doubling from 1990 to 2020)**
  - **1b raw material productivity (doubling from 1994 to 2020)**
- **Goals:**
  - **Reduction of absolute resource consumption of limited resources by increase of resource productivity**
  - **Long-term vision Factor4**
- **Operationalization:**

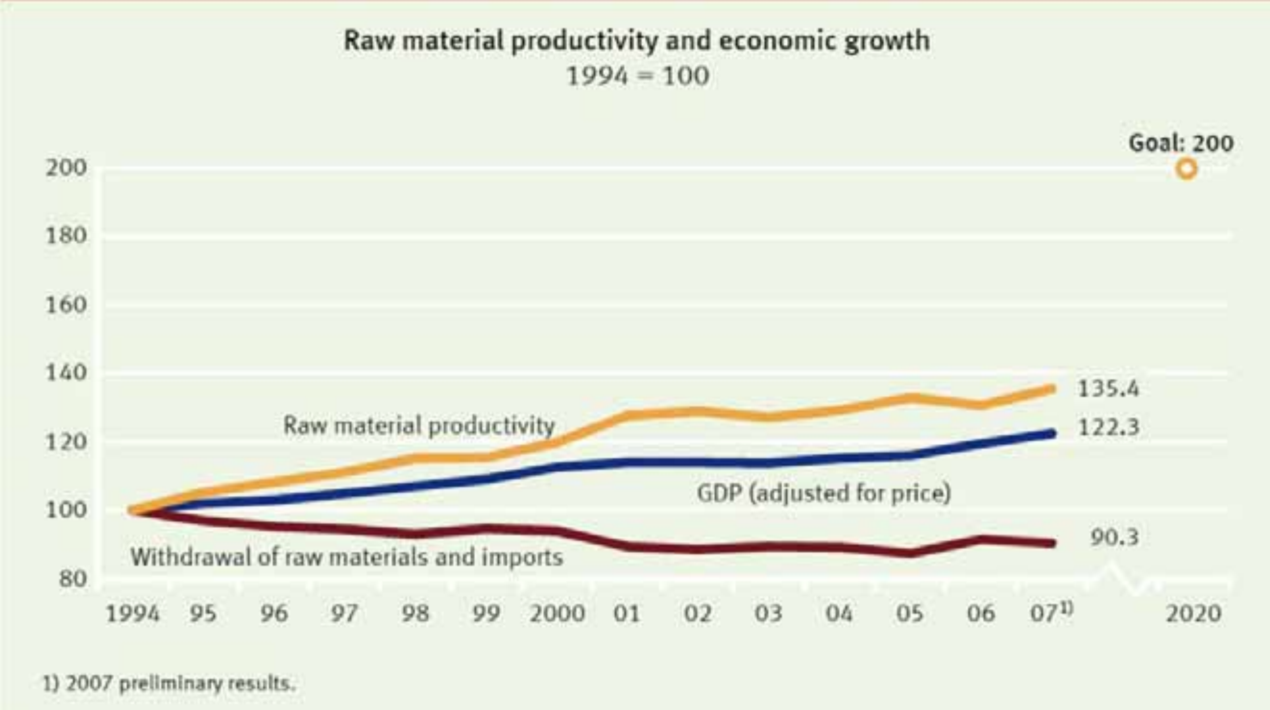
RMP = GDP / (DMI – Biomass)

Relative decoupling of energy consumption and economic growth in Germany



Source: DESTATIS 2008

Increase of raw material productivity in Germany

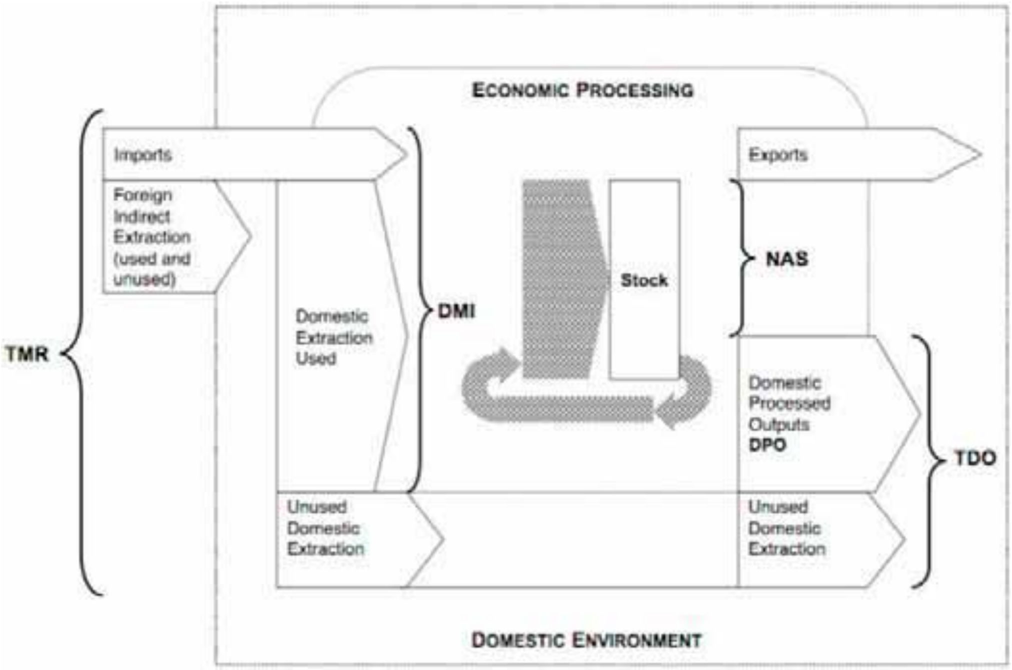


Source: DESTATIS 2008

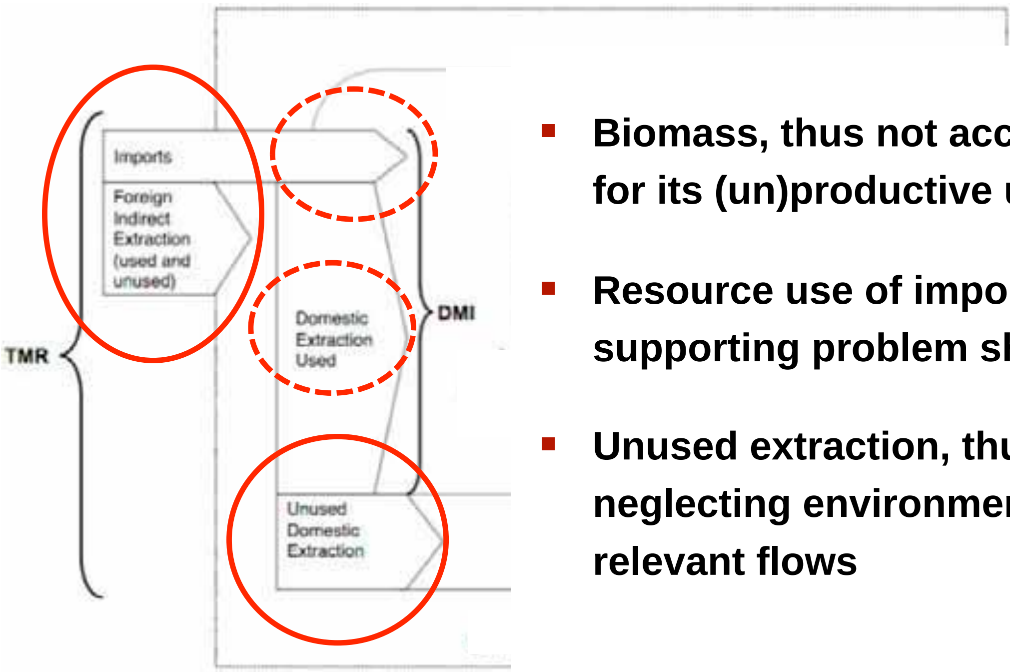
The presentation

- Why measure resource productivity?
- Some global trends
- Environmental policy and the German SDS
- **Improving the raw material productivity indicator**
- Issues for discussion

General scheme of the socio-industrial metabolism



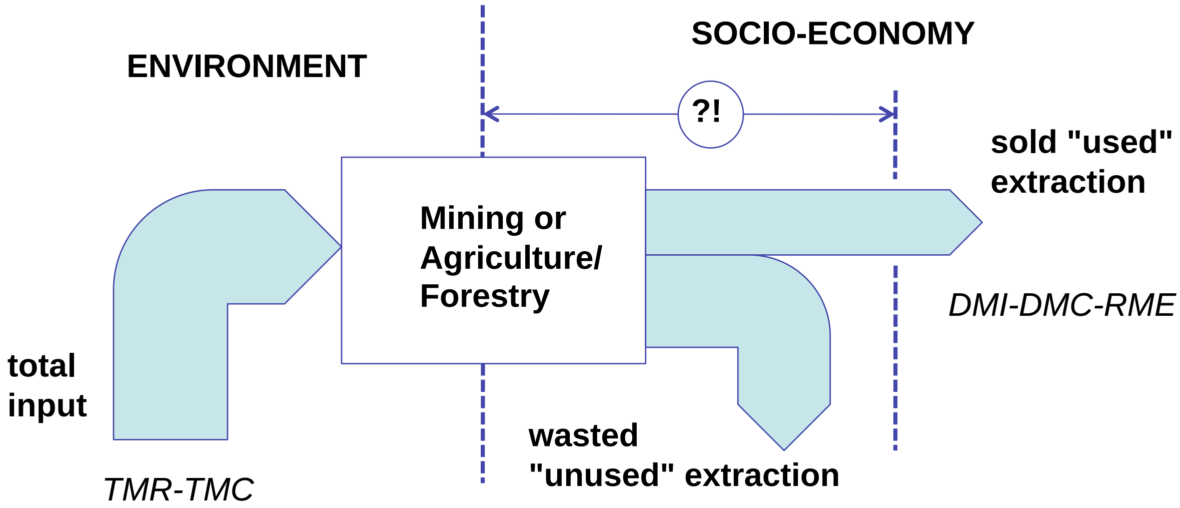
What the raw material productivity indicator does not consider



- **Biomass, thus not accounting for its (un)productive use**
- **Resource use of imports, thus supporting problem shifting**
- **Unused extraction, thus neglecting environmentally relevant flows**

In search for a (set of) more comrehensive indicators for sustainable resource use (1)

- **How far shall the system boundary be extended?**



➢ **What is the target question ?!**

In search for more comrehensive indicators for sustainable resource use (2)

- **How to consider environmental impacts associated with resource and material use?**
  - set of indicators or aggregated index?
  - how to consider multitude of materials and products?
  - generic vs. issue specific indicators?

System-turnover-based indicators of generic environmental pressure	Impact-based indicators of specific environmental pressures
Primary energy requirements	Global warming potential
Primary material requirements	Ozone depletion potential
Water consumption	Acidification potential

Possible relations to measure materials and resource productivity (OECD 2008)

Type of input measure / Type output measure	*Direct Material Input or Raw Material Input*	*Total Material Requirement (incl. indirect flows)*	*Domestic Material Consumption or Raw Material Consumption*	*Total Material Consumption (incl. indirect flows)*
GDP, Value added	Direct Material Productivity GDP/DMI Direct Raw material Productivity GDP/RMI	Total Material Productivity GDP/TMR	Domestic Material Productivity GDP/DMC Domestic Raw Material productivity GDP/RMC	Total Domestic Material Productivity GDP/TMC

Indicator candidates as denominator for a productivity measure or complementary indicator

- **Direct Material Input (DMI) or Domestic Material Consumption (DMC)**
- **DMI or DMC as Raw Material Equivalents (RME)**
- **Total Material Requirement (TMR) or Total Material Consumption (TMC)**
- **Environmental Impact Load (EVIL)**
- **Environmentally weighted Material Consumption (EMC)**

The presentation

- Why measure resource productivity?
- Some global trends
- Environmental policy and the German SDS
- Improving the raw material productivity indicator
- **Issues for discussion**

Issues for discussion – criteria for indicator assessment

- **Direction safety**
  (a) progress towards sustainable resource use
  (b) regarding generic or specific environmental impacts
- **Practicability**
  (a) data availability
  (b) effort for compilation and regular up-date
  (c) robustness: accuracy and uncertainties
- **Solid method description, available guidance**
- **International comparability and harmonization**

Wuppertal Institute
for Climate, Environment
and Energy

Many thanks for your attention !

stefan.bringezu@wupperinst.org

Material Use Indicators for Measuring Resource Productivity and Environmental Impacts
Workshop organized by Wuppertal Institute and Federal Environment Agency (UBA)
February 25-26, 2010
Presse-und Besucherzentrum der Bundesregierung, Berlin

The OECD framework of accounting for material flow and resource productivity and recent experiences in Japan

Yuichi Moriguchi, Dr. Eng.

Director
Research Center for Material Cycles and Waste Management
National Institute for Environmental Studies, Japan

Visiting Professor, Graduate School of Frontier Sciences, The University of Tokyo

Vice Chair (Ex-Chair for 2003-2008), OECD/EPOC/WGEIO

Member, International Panel for Sustainable Resource Management, UNEP

Contents of speech

- **Background: Massive material flows of industrialized economies**
- **Progress in Material Flow Analysis/Accounting/Indicators**
  - Interaction between international activities and nation-specific progress
  - Interaction between methodological experts and policy users
  - Progress in expert communities, e.g. ConAccount, ISIE
- **OECD's activities on material flows and resource productivity**
  - Council Recommendations (1st CR on MF/RP 2004, 2nd CR on RP 2008)
  - OECD's set of guidance documents
  - Co-operations with other int'l organizations (EEA, EUROSTAT, UNEP)
- **Recent experiences in Japan**
  - Introduction of of macro MF indicators and numerical targets in Japanese 1st Fundamental Plan for establishing a Sound Material-Cycle Society
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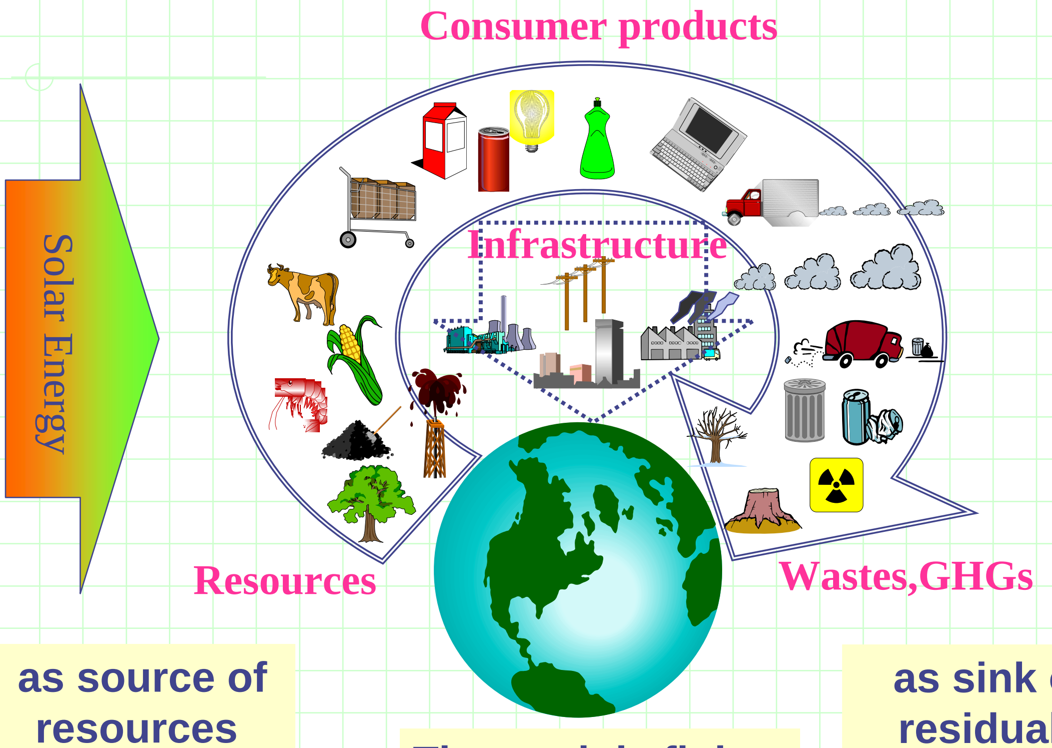
  - Use of MF approach in industries (e.g. in environmental reporting)
- **Conclusion**

Massive flow of materials on the globe



as source of resources

The earth is finite

as sink of residuals

Why do material flows matter ?

- **Dematerialization**

  Total size of MF, scarcity of resources, scarcity of waste dumping site, etc.

Proxy of environmental impacts ?
Common background of environmental problems?

- **Detoxification**

  Minimization of use and release of critical /hazardous substances (pollutants)

Bringezu & Moriguchi (2001) in Handbook of Industrial Ecology

Alternative views to rationalize the need to reduce the total requirement for materials

In addition to resource issues (price, scarcity, equitable use, etc.), we have rationale from perspectives of environmental impacts.

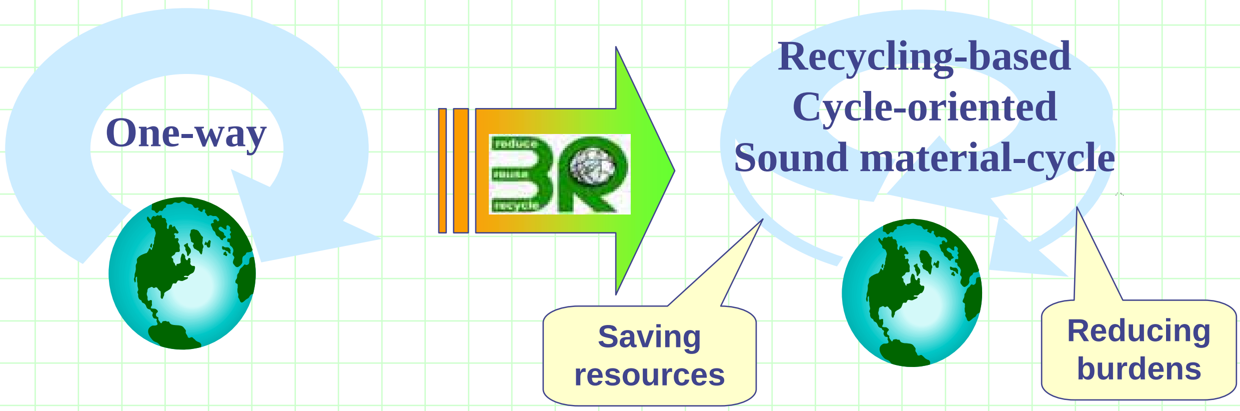
- We need to reduce the massive environmental pressures in material resources extraction
- Dematerialization directly contributes to prevention of the generation of massive solid wastes at the end-of-life of material resources
- Dematerialization contributes to a reduction of life-cycle energy consumption, greenhouse gas emissions, and other environmental impacts.

Bringezu & Moriguchi (2001) in Handbook of Industrial Ecology

Transition of socio-economic structure

Mass-production, mass-consumption, mass-disposal society

Sound material cycle society (SMCS)



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  - Progress in expert communities, e.g. ConAccount, ISIE

- **OECD's activities on material flows and resource productivity**
  - Milestones since 1st Council Recommendation
  - OECD's guidance documents
  - Co-operations with other int'l organizations (EEA,EUROSTAT, UNEP)

- **Recent experiences in Japan**
  - Introduction of of macro MF indicators and numerical targets in Japanese 1st Fundamental Plan for establishing a Sound Material-Cycle Society
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Chronology of international interactions(1990-2000)

- Mainly between Japan and Europe (in particular Germany) -

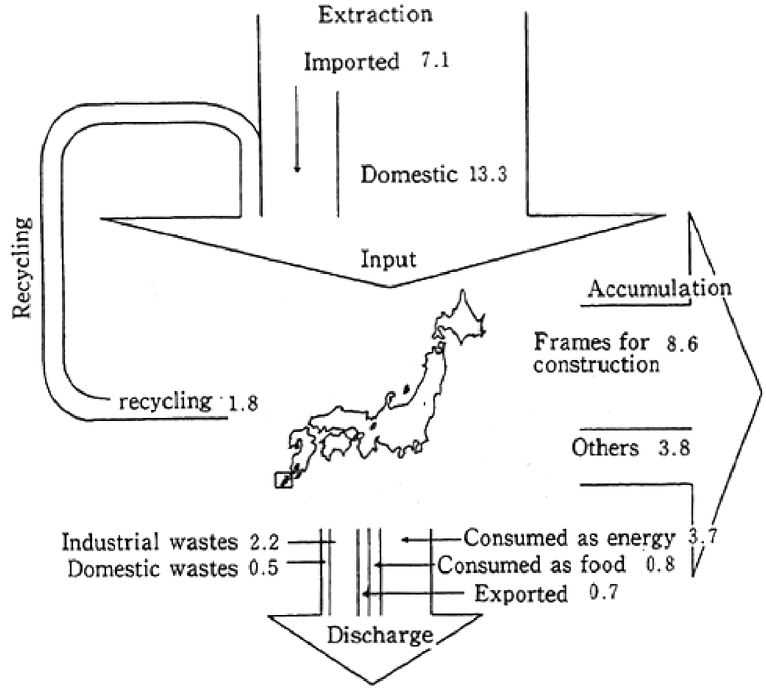
- 1991 The term "Junkan-gata-shakai (Sound Material-cycle Society)" was proposed by an expert committee of Japan Environment Agency
- Since 1992 Material balance of Japan has been published on "White paper" (Quality of the Environment Report)
- Mid 1990s European experts noticed Japanese activity
- 1995 SCOPE Workshop on Indicators of Sustainable Development at Wuppertal Institute

  Initiation of International joint study (GER, JPN, USA, NET, +AUT)
- Late 1990s, WRI reports (Resource Flows, The Weight of Nations)

  Methodological progress in ConAccount, ISIE, etc.
- 2000 Fundamental Law for establishing a Sound Material Cycle Society
- 2000 OECD MFA Seminar

Material balance of Japan published on "White paper" 1992

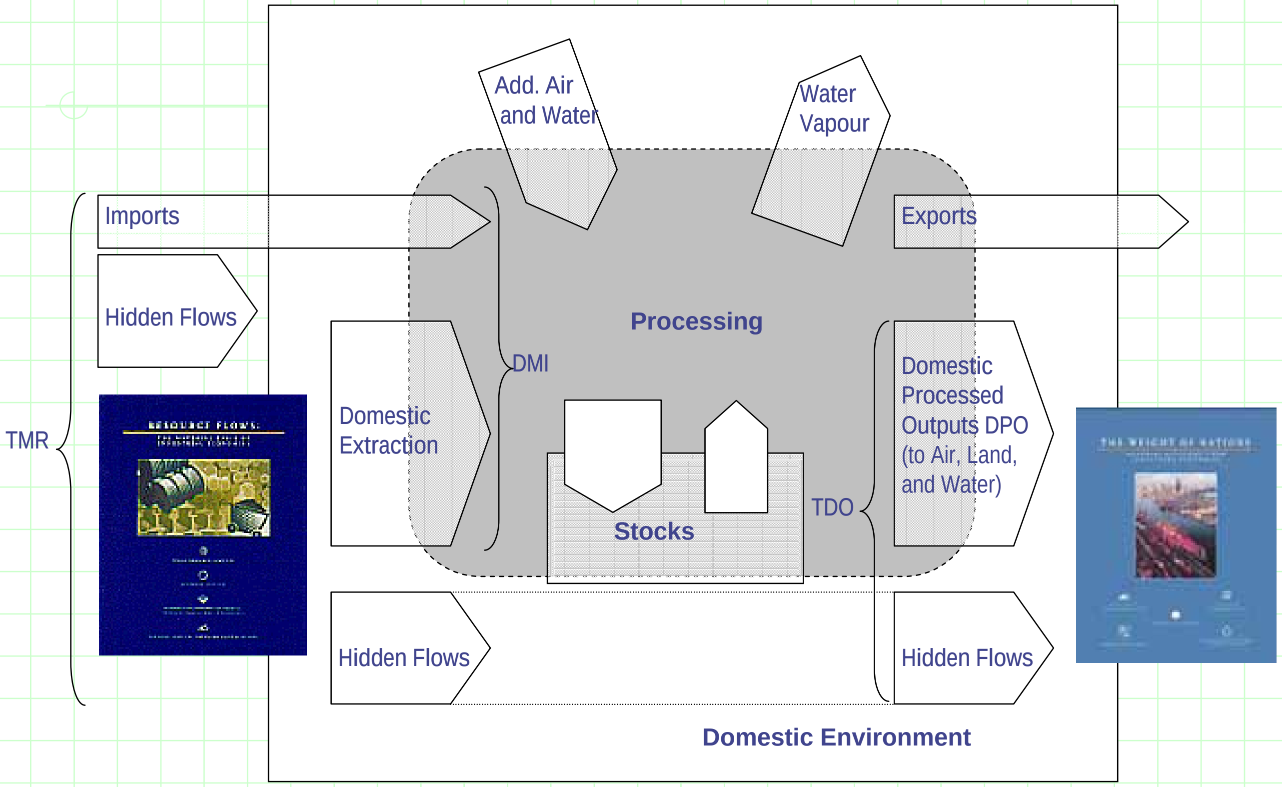
Fig. 3-1-18 Japan's Material Balance (FY 1990 ; in hundred million tons)



Source: Estimated by the Environment Agency based on various data

Source:Environment Agency of Japan, Quality of the Environment, 1992

A framework for capturing macroscopic material flows



Source WRI(2000)

Key international activities for MFA

Research community

- International Joint Study (AUT,GER,JPN,NET,USA)
- ConAccount
- Gordon Conference on Industrial Ecology
- ISIE(International Society for Industrial Ecology)

International organizations

- OECD(Environmental Accounting, De-coupling indicator, Waste prevention, Sustainable Material Management)
- EEA/ETCWMF(ETCRWM)
- EUROSTAT: Methodological guide
- UNSTAT:SEEA

Chronology of international interactions(2000-)

- 2000 Fundamental Law for establishing a Sound Material Cycle Society
  OECD MFA Seminar
- 2003 MF Indicators and targets in 1st Japanese SMCS plan
  Japanese proposal at G8 meeting (MFA studies)
- 2004 OECD Council Recommendation on MF/RP
  2004-2006 OECD MFA WS in Helsinki, Berlin, Rome
  2004 Japanese proposal at G8 summit (3R initiative)
- 2005 3R Ministerial (OECD's proposal to host OECD/UNEP Conference)
- 2007 OECD/Japan Seminar for MF/RP
  Inaugural meeting of UNEP Resource Panel
- 2008 2nd Japanese SMCS plan
  (revised indicators, incl. monitoring of TMR)
  OECD 2nd Council Recommendation on RP
  OECD-UNEP Conf., OECD/EPOC Ministerial
  G8 Environmental Ministerial, G8 Summit

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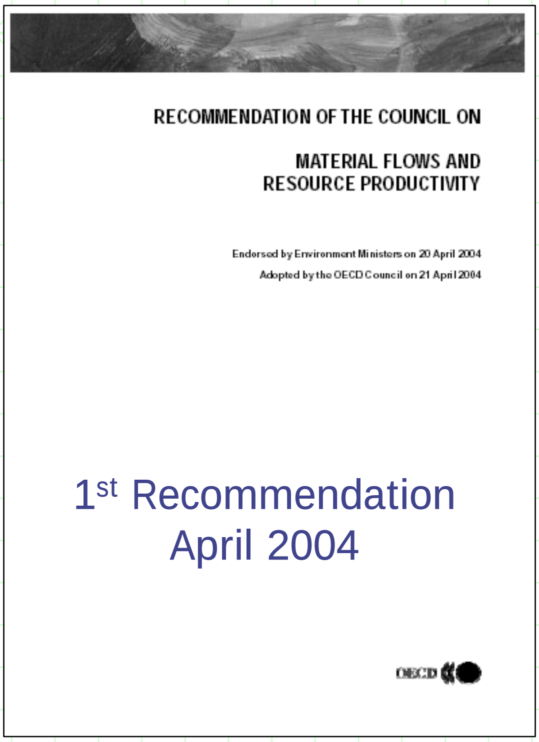
OECD Council Recommendations

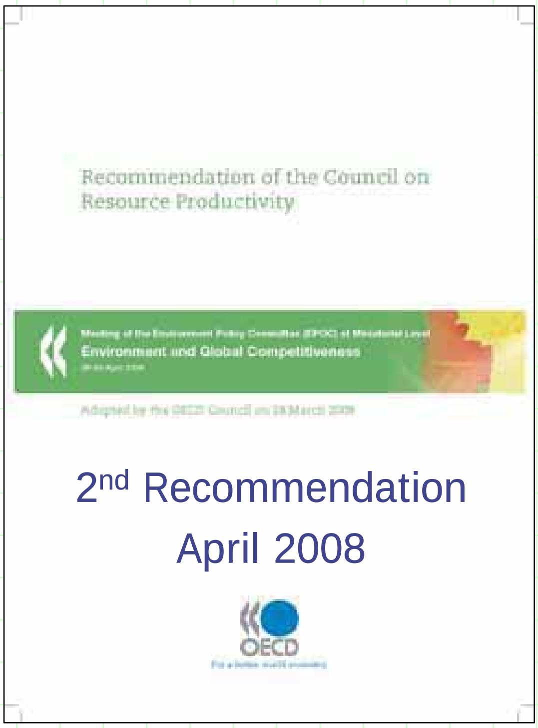

RECOMMENDATION OF THE COUNCIL ON

MATERIAL FLOWS AND RESOURCE PRODUCTIVITY

Endorsed by Environment Ministers on 20 April 2004

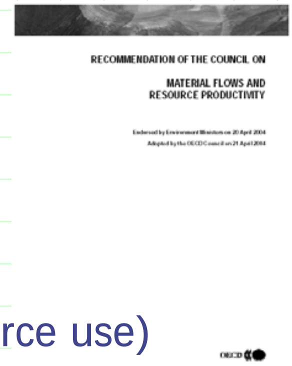
Adopted by the OECD Council on 21 April 2004

1st Recommendation
April 2004


Recommendation of the Council on Resource Productivity

2nd Recommendation
April 2008

2004 Council Recommendation on MF/RP (1)


RECOMMENDATION OF THE COUNCIL ON

MATERIAL FLOWS AND RESOURCE PRODUCTIVITY

Recommends that member countries:

1. improve information on Material Flows
2. further develop and use indicators

   (with respect to the sustainability of resource use)
3. promote the development and use of MFA at macro and micro levels
4. link environmental and economic related information
5. cooperate and develop common methodologies and measurement systems

2004 Council Recommendation on MF/RP (2)


RECOMMENDATION OF THE COUNCIL ON

MATERIAL FLOWS AND RESOURCE PRODUCTIVITY

Instructs the Environmental Policy Committee:

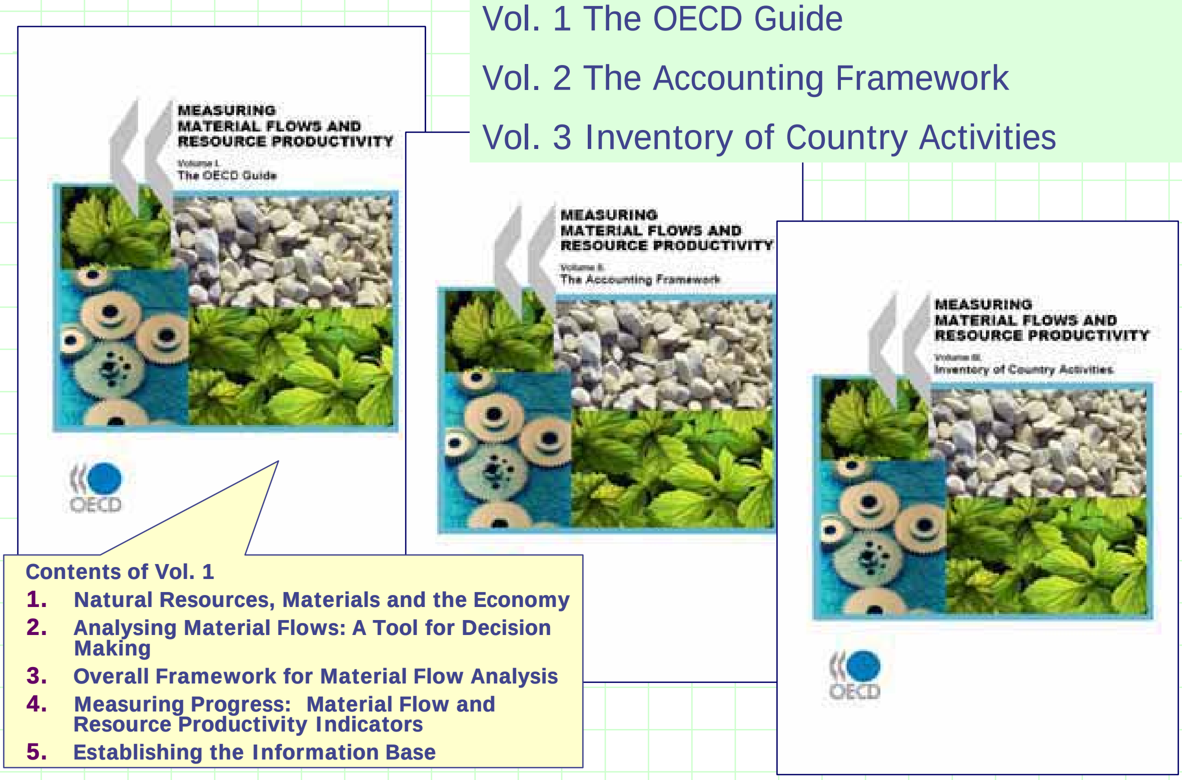
1. to support and facilitate member countries effort
2. to continue efforts to improve methods and indicators
3. to develop a guidance document to assist member countries
4. to carry out these tasks in cooperation with other OECD bodies and other international organizations
5. to report to the Council on progress achieved by Member countries within three years of its adoption

OECD's set of guidance documents

Vol. 1 The OECD Guide

Vol. 2 The Accounting Framework

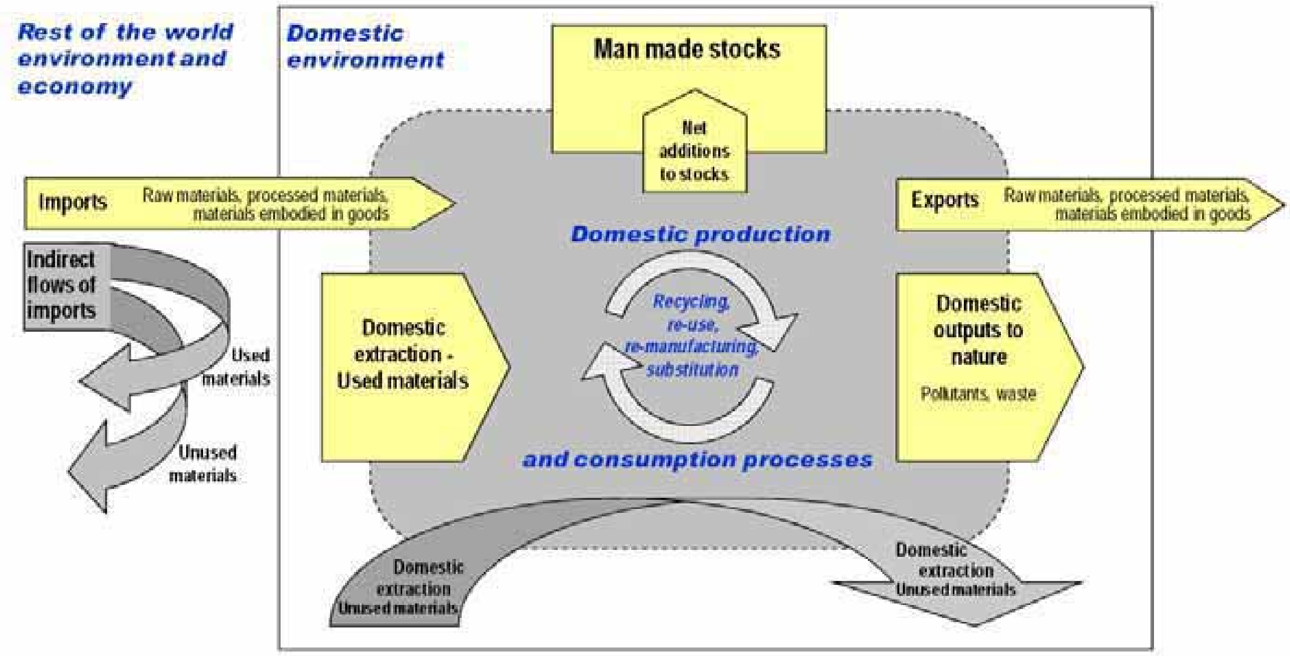
Vol. 3 Inventory of Country Activities



Contents of Vol. 1

1. Natural Resources, Materials and the Economy
2. Analysing Material Flows: A Tool for Decision Making
3. Overall Framework for Material Flow Analysis
4. Measuring Progress: Material Flow and Resource Productivity Indicators
5. Establishing the Information Base

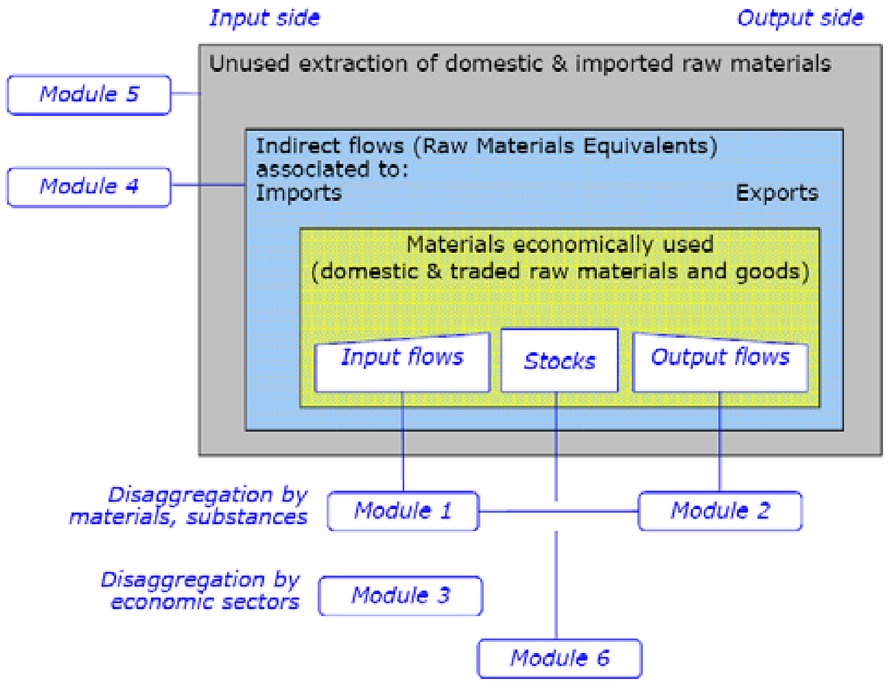
Economy-wide material balance scheme



Source: OECD(2008) Measuring material flows and resource productivity Volume I The OECD Guide

A stepwise (modular) approach for MF accounts

Hierarchy and sequence of steps for a system of national MF accounts



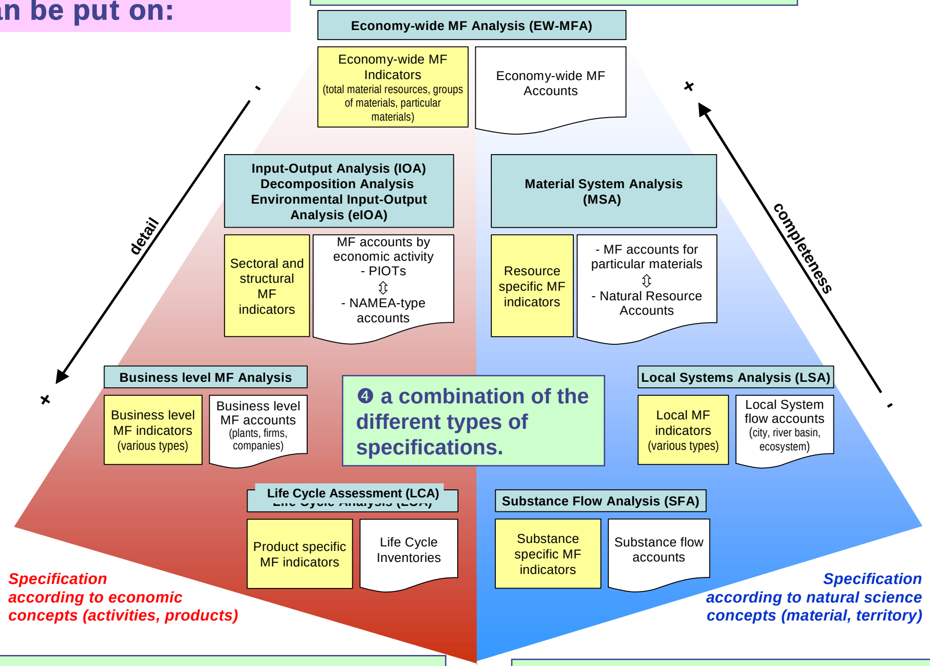
Each of these modules provides a basis for deriving material flow indicators.

Source: OECD(2008) Measuring material flows and resource productivity Volume I The OECD Guide

Architecture and level of application of MFA tools

When analysing material flows, emphasis can be put on:

❶ all materials entering and leaving the national economy (top of the Figure);



❷ the industry level, enterprise level, and product level, from product groups down to specific products (left hand side of Figure);

❸ certain material and substance flow systems, from the national down to the local level (right hand side of Figure);

Source: OECD(2008) Measuring material flows and resource productivity Volume I The OECD Guide

Material flow related analyses and associated issues of concern

Issues of concern	Specific concerns related to environmental impacts, supply security, technology development			General environmental and economic concerns related to the throughput		
	within certain businesses, economic activities, countries, regions			of substances, materials, manufactured goods		
	associated with			*at the level of*		
Objects of primary interest	Substances	Materials	Manufactured goods	Businesses	Economic activities	Countries, regions
	chemical elements or compounds e.g. Cd, Cl, Pb, Zn, Hg, N, P, C, CO2, CFC	raw materials and semi-finished goods e.g. energy carriers, metals (ferrous, non-ferrous), sand and gravel, timber, plastics	e.g. batteries, cars, computers	e.g. firms, companies, plants, medium sized and big enterprises, MNEs	e.g. production sectors, chemical industry, iron and steel industry, construction, mining	e.g. aggregate mass of materials (& related materials mix), groups of materials, selected materials
Type of analysis	Ia Substance Flow Analysis	Ib Material System Analysis	Ic Life Cycle Analysis	IIa Business level MF analysis	IIb Input-Output Analysis	IIc Economy-wide MF Analysis
	⇳	⇳	⇳	⇳	⇳	⇳
Type of measurement tool	Substance Flow Accounts	Individual Material Flow Accounts ✪	Life Cycle Inventories (MF Inventories)	Business Material flow accounts	Physical Input-Output Tables ✪ ⊙, NAMEA-type approaches ⊙	Economy-wide Material Flow Accounts ✪

✪: MFA tools using the materials balance principle. ⊙: MFA tools using national accounting principles fully in line with the SEEA.
Source: OECD, based on Bringezu and Moriguchi 2002.

2008 Council Recommendation on RP (1)

Recommends, with regard to the analysis of the material flows and their environmental impacts, that member countries:

1. Improve the scientific knowledge concerning the environmental impacts and costs of resource use throughout the entire life cycle of materials and the products
2. Upgrade the extent and quality of data on material flows within and among countries and the associated environmental impacts
3. Work to improve and use soundly based, relevant and internationally compatible material flow accounts
4. Further develop and promote the use of indicators for the assessment of the efficiency of material resource use
5. Co-operate with non-Member Economies to strengthen their capacity for analysis of material flows and the associated environmental impacts
6. Share OECD guidance and experience on measurement and analysis of material flows and resource productivity with all relevant ministries and departments of government, research and other non¬governmental organisations, and members of the private sector

2008 Council Recommendation on RP (2)

Recommends, with regard to the policies concerning the improvement of resource productivity, that member countries:

1. Consider the use of information about material flows and their environmental impacts for planning purposes, as appropriate in a national context, including, for instacnce, using such informatipn for target setting, and share these experiences and best practices with other Member countries
2. Promote integrated life-cycle-oriented approaches, such as 3R policies (Reduce, Reuse, and Recycle), sustainable materials management and sustainable manufacturing
3. Further develop and promote the use of new technologies and innovations aimed at improving resource productivity
4. Encourage co-operation and sharing of best practices among enterprises
5. Contribute to the establishment of framework conditions that improve resource productivity through economic instruments
6. Co-operate to ensure that policy measures taken to improve resource productivity are efficient in economic terms, effective in environmental terms and equitable in social terms
7. Co-operate with non-Member Economies to strengthen their capacity for developing and implementing policies concerning the improvement of resource productivity.

2008 Council Recommendation on RP (3)

Instructs the Environment Policy Committee:

1. To review existing policies and practices and contribute to elaborating common principles and policy guidelines on resource productivity and sustainable materials management.
2. To strengthen its capacity for material flow analysis at the international level, with particular focus on key materials, on direct and indirect flows and their environmental impacts
3. To further develop and where appropriate promote the use of material flow analysis, resource productivity indicators, and methods for assessing the environmental impacts of resource use.
4. To support Member countries' efforts in developing and implementing integrated policies for managing natural resource and materials throughout their life cycles,
5. To assist non-Member Economies in developing and implementing policy frameworks and measurement systems
6. To carry out these tasks in co-operation with other appropriate OECD bodies, other international organisations such as UNEP (including the Resource panel) and G8 (including the 3R initiative) and the private sector.
7. To report to the Council on progress achieved in implementing this Recommendation, within five years of its adoption

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- **Conclusion**

Law and Regulation

Fundamental Environmental Law ⟷ Fundamental Plan

Fundamental Law for Establishing a Sound Material-Cycle Society ⟷ Fundamental Plan

1st 2003, 2nd 2008

(Establishment of General Systems)

Waste Management and Public Cleansing Law

Law for Promotion of Effective Utilization of Resources

(Regulations according to the characteristics of respective Items)

Container and Packaging	Home Appliances	Construction Materials	Food Wastes	End-of-life Vehicles

Law on Promoting Green Purchasing

The Fundamental Plan for Establishing a Sound Material-Cycle Society (Outline)

Present Situation and Problems

Present Situation: Unsustainable Activity Patterns of the 20th Century
Problems: ・Realization of Social and Economic Systems Based on Recycling
・Solution of Waste Problems

Image of a sound material-cycle Society

Lifestyle: Using high quality goods with care, "Slow" Lifestyle
Manufacturing: DfE (Design for Environment), Long-life products, Lease & Rental

Quantitative Targets: FY2000-2010

1 Targets for Indicators Based on Material Flow Accounts

(1) "Input": Resource Productivity **FY2010: About 390 thousand yen/ton** (About 40% improvement from FY 2000)

(2) "Recycling": Rate of Reuse and Recycling **FY2010: About 14%** (About 40% improvement from FY 2000)

(3)"Output": Final Disposal Amount **FY2010: About 28 million tons** (Almost 50% reduction from FY2000)

2 Targets for Effort Indicators

・Reducing the quantity of municipal solid waste: reducing the amount of garbage discharged from households per person per day by 20% from FY2000

・Expanding the sound material-cycle business market

Efforts of Entities

The State: Fostering partnerships among social stakeholders, leading activities for establishing a sound material-cycle society, etc.

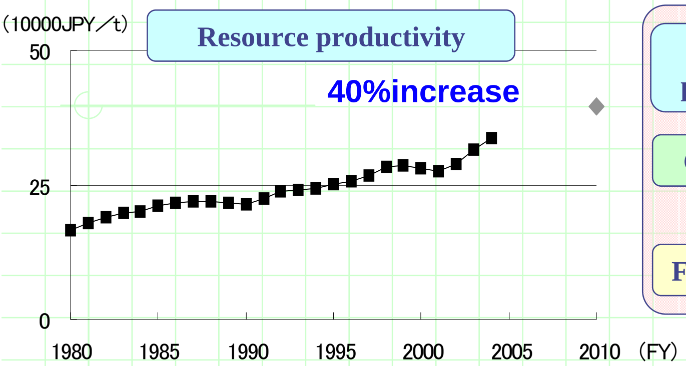
Citizens: Changing their lifestyle to establish a sound material-cycle society, etc.

Business organizations: Promoting appropriate reuse, recycling and disposal of wastes based on EPR, etc.

NPOs/NGOs: Promoting activities that contribute to establishing a sound material-cycle society, etc.

Local governments: Enforcing laws and regulations, acting as a coordinator among various local entities, etc.

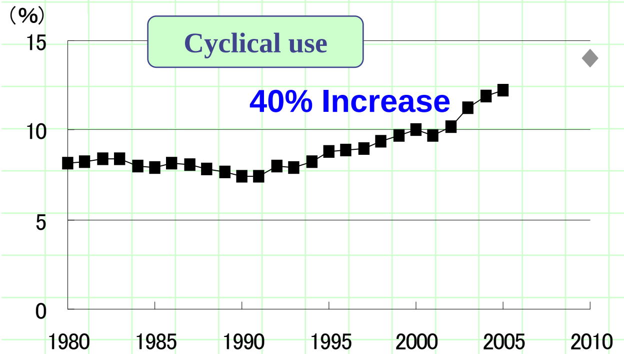
Trend of 3 material flow indicators towards target

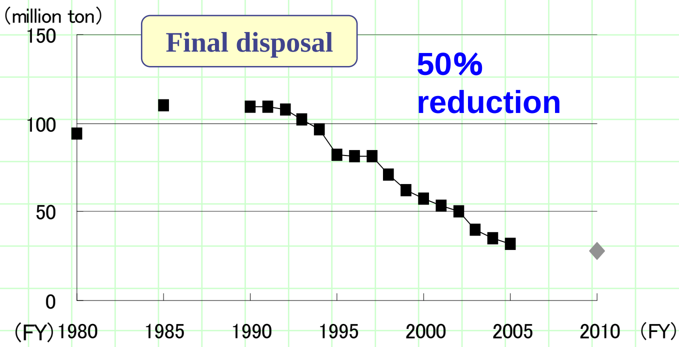


Resource productivity = $\frac{\text{GDP}}{\text{Direct Material Input (DMI)}}$

Cyclical use = $\frac{\text{Cyclically used amount}}{\text{DMI} + \text{Cyclically used amount}}$

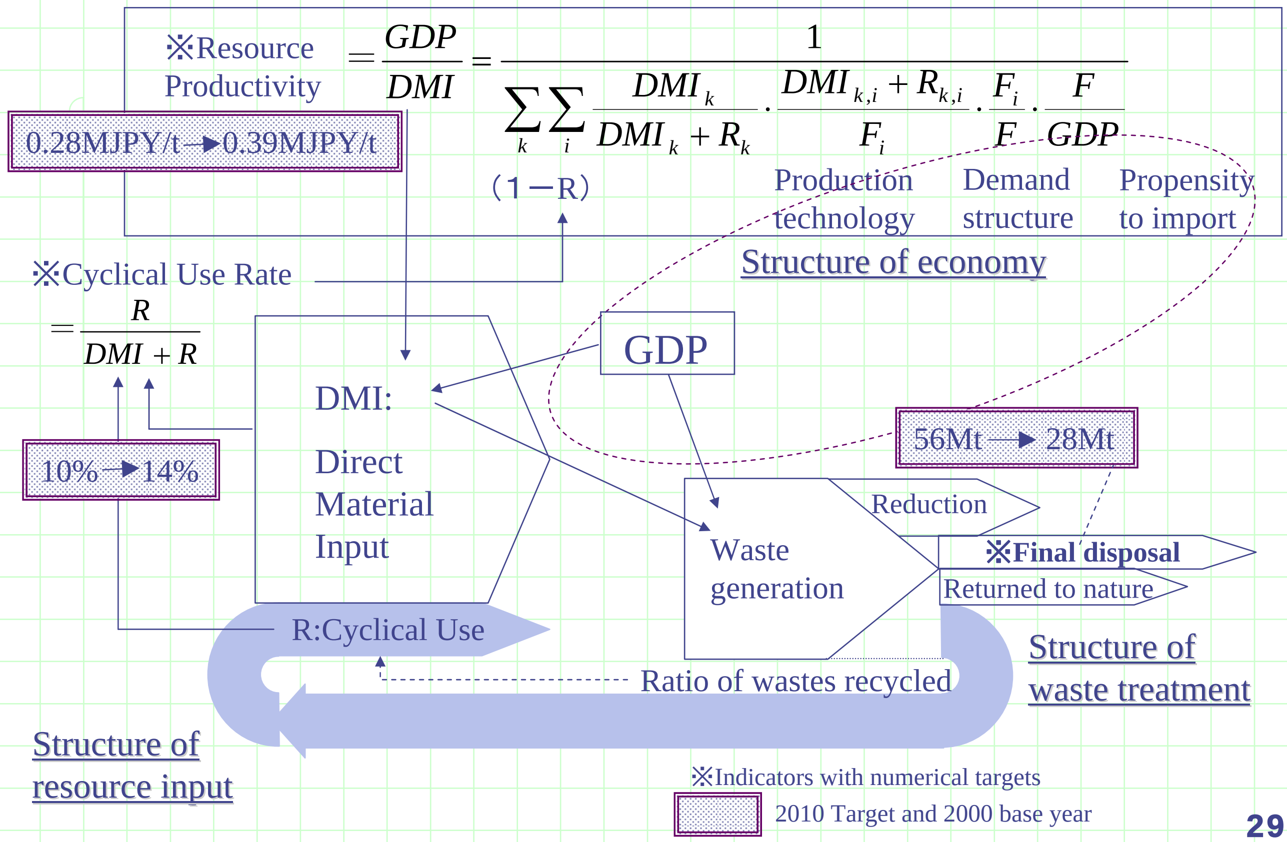
Final disposal = Final disposal of solid wastes





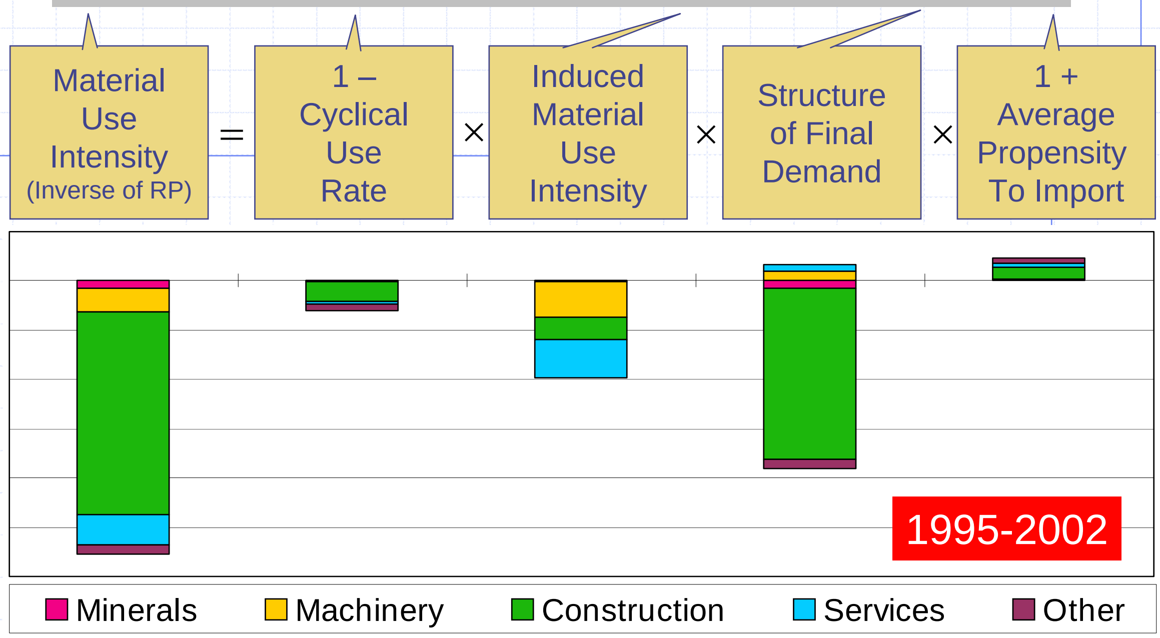
Revised targets for 2015 were set by the revision in March 2008

Framework of a Material Flow Model used for setting targets



Decomposition analysis of resource productivity (by materials)

$$\frac{DMI}{GDP} = \sum_k \sum_i \frac{DMI_k}{(DMI_k + R_k)} \times \frac{(DMI_{k,i} + R_{k,i})}{F_i} \times \frac{F_i}{F} \times \frac{F}{GDP}$$



Source: Hashimoto S. et al., *Journal of Industrial Ecology*, 12(5-6), 657 – 668, 2008

The Extension of Indicators under the 2nd Fundamental Plan for Establishing a Sound Material Cycle Society (Mar. 2008)

(material flow based indicators)

1 Indicators with target setting (as compared with 2000)

1) "Input": Resource Productivity	increase	2010 40%	2015 60%
2) "Recycle": Cyclical use Rate	increase	2010 40%	2015 40-50%
3) "Output": Final Disposal Amount	reduction	2010 50%	2015 60%

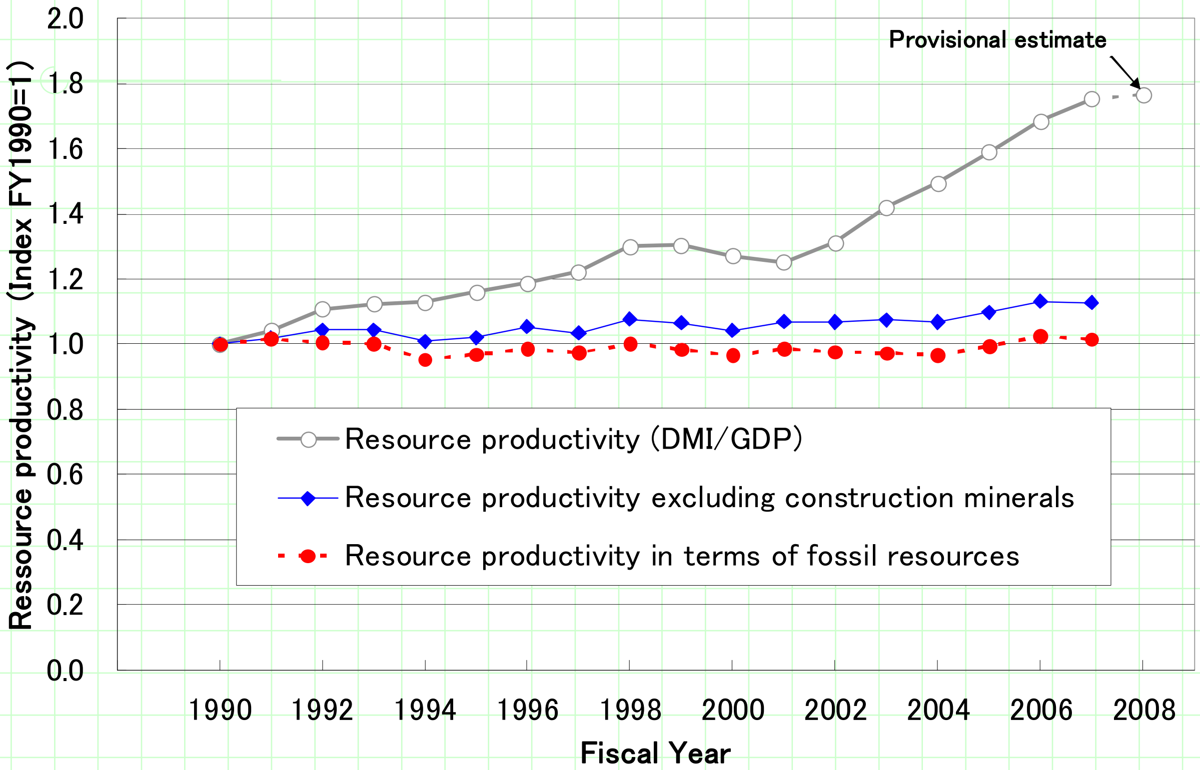
2 Supplementary indicators with target setting

1) Resource productivity not including resource input of construction minerals
2) Collaboration with the action for low carbon society
   - the amount of reduction by the measures of waste sector to reduce GHGs emission
   - GHGs emission associated with waste sector and fossil fuels to be substituted by waste power generation (monitoring)

3 Indicators to monitor progress

1) Resource productivity related to fossil fuels
2) Input rate of biomass resources
3) Hidden Flow and TMR (Total Material Requirement) (the example of estimation: about 21 times larger than the import of metal resources)
4) Indicators considering international resource circulation
5) Resource productivity of each industrial sector

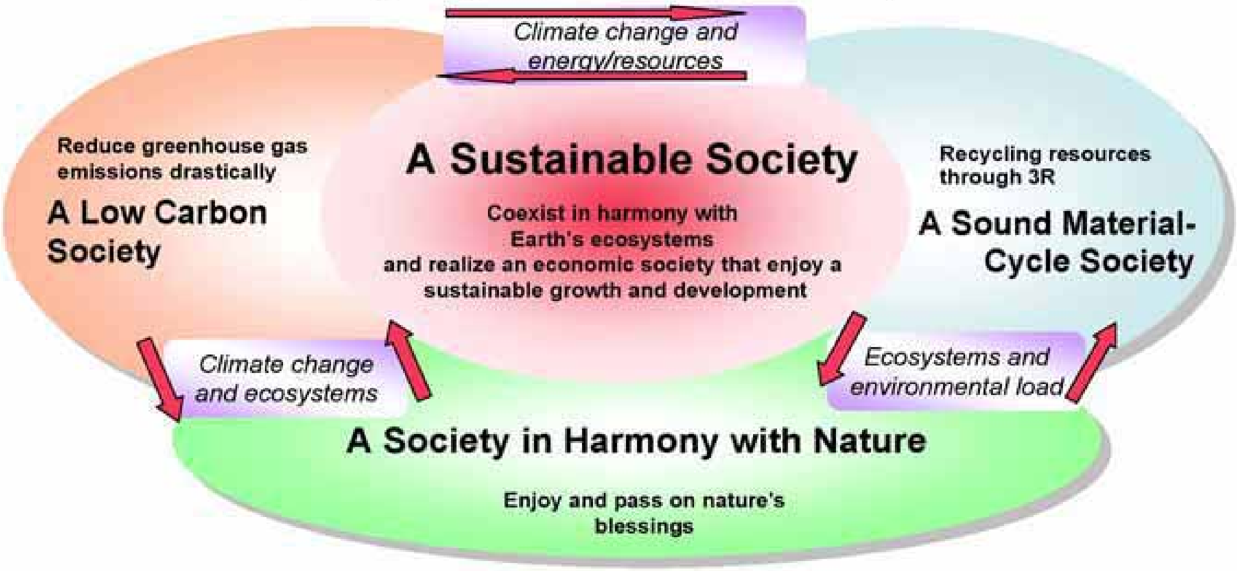
Trends of Japan's Resource Productivity with different scope



Japan's strategy for a Sustainable Society

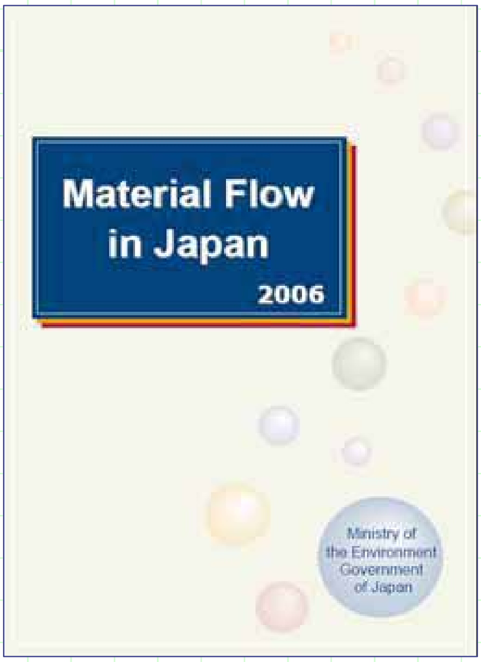
(Cabinet Meeting Decision on June 1, 2007)

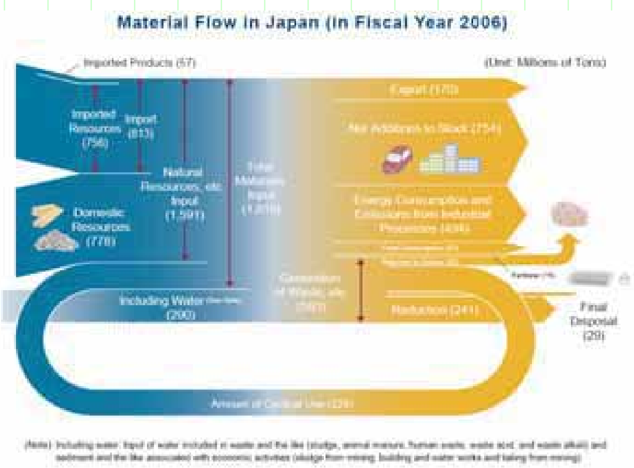
Integrating 3 Aspects of a Sustainable Society



http://www.env.go.jp/en/focus/070606.html

English booklet: Material Flow in Japan





http://www.env.go.jp/en/recycle/smcs/material_flow/2006_en.pdf

Contents of speech

- **Background: Massive material flows of industrialized economies**

- **Progress in Material Flow Analysis/Accounting/Indicators**
  - Interaction between international activities and nation-specific progress
  - Interaction between methodological experts and policy users
  - Progress in expert communities, e.g. ConAccount, ISIE

- **OECD's activities on material flows and resource productivity**
  - Council Recommendations (1st CR on MF/RP 2004, 2nd CR on RP 2008)
  - OECD's set of guidance documents
  - Co-operations with other int'l organizations (EEA, EUROSTAT, UNEP)

- **Recent experiences in Japan**
  - Introduction of of macro MF indicators and numerical targets in Japanese 1st Fundamental Plan for establishing a Sound Material-Cycle Society
  - New MF indicators with/without numerical targets in revised 2nd FPSMCS
  - Use of MF approach in industries (e.g. in environmental reporting)

- **Conclusion**

Key methodological questions to meet policy needs

- Attribution of MFs to national production or consumption to ensure international comparability of MF indicators
- Disaggregation by sectors and by materials to meet the needs from other users than national policy makers
- Quantification of hidden flows (system boundary, data availability)
- Linking MF information with specific environmental problems (impact, damage-based quantification)
- Better understanding of upstream (e.g. mining) and downstream (e.g. waste management) flows and their environmental impacts
- Compilation of internationally comparable/common database

OECD, IE, ConAccount and other MFA meetings in last 15 years

- SCOPE WS on Indicators of SD, November 1995, **Wuppertal**
- ConAccount Workshop, January 1997, Leiden
- ConAccount Conference, September 1997, **Wuppertal**
- 1st Gordon Conference on IE, June 1998, New London (NH)
- ConAccount Workshop, November 1998, Amsterdam
- 2nd Gordon Conference on IE, June 2000, New London (NH)
- OECD MFA / WMF-RP seminar, October 2000, Paris
- ConAccount Conference, April 2001, Stockholm
- 1st ISIE Conference, November 2001, Noordwijkerhout
- 3rd Gordon Conference on IE, June 2002, New London (NH)
- 2nd ISIE Conference, June-July 2003, Ann Arbor (MI)
- ConAccount Workshop, October 2003, **Wuppertal**
- Int'l expert WS on MFA & RP, November 2003, **Tokyo**
- OECD workshop on MFA, June 2004, Helsinki
- 4th Gordon Conference on IE, August 2004, Oxford
- ConAccount Meeting, October 2004, Zuerich
- OECD workshop on MFA, May 2005, **Berlin**
- 3rd ISIE Conference, June 2005, Stockholm
- OECD workshop on SMM, November 2005, Seoul
- OECD workshop on MFA, May 2006, Rome
- 5th Gordon Conference on IE, August 2006, Oxford
- ConAccount Meeting, September 2006, Vienna
- 4th ISIE Conference, June 2007, Toronto
- OECD/Japan Seminar on MF/RP, September 2007, **Tokyo**
- OECD-UNEP Conference on Resource Efficiency, April 2008, Paris
- 6th Gordon Conference on IE, June 2008, New London (NH)
- ConAccount Meeting, September 2008, Prague
- 5th ISIE Conference, June 2009, Lisbon
- ConAccount Meeting, November 2010, **Tokyo**

http://www.isieapmfa.info/index.html

Measuring Material Use and Resource Productivity in Europe

Stephan Moll (Eurostat)

Workshop: "Material Use Indicators for Measuring Resource Productivity and Environmental Impacts", Berlin 25-26 February 2010

eurostat

Overview – main messages

- Eurostat …
- has been fostering the methodological harmonisation of measuring material use in Europe (EW-MFA Guide
- since 2007: European-wide data collections
- to date: DMC published as aggregated material use indicator (GDP/ DMC = resource productivity)
- future: DMC in raw material equivalents (RME)

eurostat

Methodological harmonisation

- Eurostat Task Forces on material flow accounts
- Method: economy-wide material flow accounts and derived indicators (Guide 2001)
  - domestic extraction (DEU)
  - imports and exports (trade)
  - derived indicators:
    - Domestic Material Input (DMC) Direct Material Inputs (DMI)

- on country level:
- Strengthening capacities in national statistical institutions (NSIs)
- Financial supports (grants), training workshops

Producing data

- started with Eurostat estimates for DEU, trade, DMC and DMI

- since 2007: data collection from NSIs (bi-annually)
- electronic questionnaire comprising tables for DEU, trade, DPO
- gentlemen agreement with NSIs (future: legal base ?)

.

Producing data – 2009 EW-MFA survey

- deadline: September 2009
- response rate: 26 countries (EU, EFTA, CC)
- ongoing: data checking & validation
- next steps: gap-filling and estimation of EU aggregates
- publish: around may 2010

=> more details (Working Group paper):
http://circa.europa.eu/Public/irc/dsis/envirmeet/library?l=/environmental_24032010&vm=detailed&sb=Title

Resource Productivity

- Eurostat uses GDP/DMC (€/kg)
- = Sustainable Development Indicator (SDI)
  http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/indicators/theme2
- = Structural Indicator (Lisbon strategy)
  http://epp.eurostat.ec.europa.eu/portal/page/portal/structural_indicators/indicators/environment

- currently published data = 2007 survey

Resource Productivity

- However …
- DMC as an aggregate material use indicator is perceived sub-optimal (best available but not best wanted)

- Intrinsic asymmetry of DMC:
  - DEU is measured in raw materials
  - Trade is measured in products

Future – the way ahead…

- Strategy towards DMC_{RME}:
- …to overcome asymmetry …

- transforming traded products into raw material equivalents (RME)
- providing default European RME-coefficients
- for ca. 10000 products (CN 8-digit)
- for main material categories (biomass, minerals, fossils)
- assisting contract running until December 2010
- decision on next steps depends on results (data robustness)

Future – the way ahead…

- adding DEU to an environmentally-extended Input-Output framework (e.g. exports in RME, modelling)
- later: adding imports in RME to eeIO

- Hoping that the Legal Base for reporting is adopted by countries

.

Measuring DMI, DMC, TMR and TMC of Germany

Dr. Helmut Schütz
Mathieu Saurat

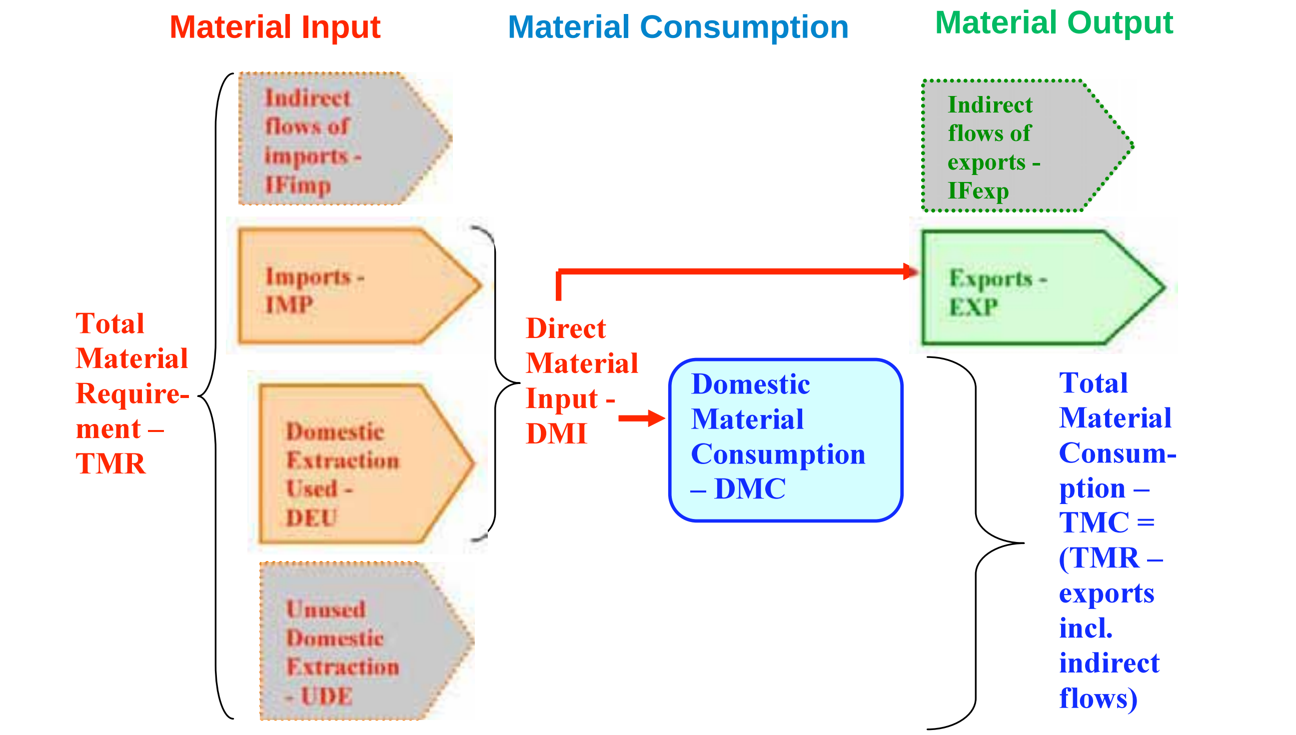
Material Flows and Resource Management
Wuppertal Institute

Presentation
Workshop „Material Use Indicators for Measuring Resource Productivity and Environmental Impacts“
25 February 2010
Berlin

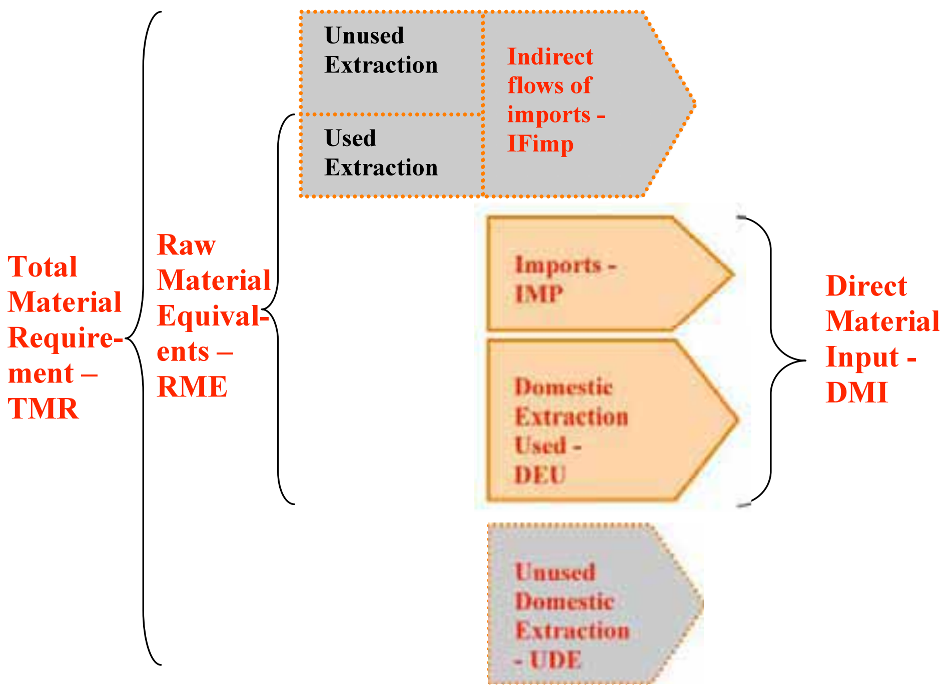
The presentation

- **Definition, Objectives, Foundations**
- **Practical application**
- **Some old and some new results**
- **Policy relevance**
- **Development requirements and perspectives**

Material flows and derived indicators



Material Input Indicators



Definitions, Objectives, Foundations

	DMI	DMC	TMR	TMC
Definition	direct input for use	material directly used for own consumption	total 'material base' of an economy	total primary material use for domestic consumption
Objectives	determines the amount of subsequent wastes and emissions from manufacturing and households, mainly in the reporting country, partly in the countries receiving the exports produced from DMI.	volume of DMC will be released sooner or later as processed waste or emissions on the territory	The relation of domestic and foreign TMR allows to monitor the shift of resource supply and associated environmental burden between regions	The relation of TMC to the exports and their indirect flows indicates how much of the TMR is associated to domestic consumption vs. being used to produce the exports.
	does not contain unused domestic extraction and indirect resource flows		TMR may be interpreted as indicator of generic environmental pressure which grows with the turnover of primary materials (analogously to primary energy and water)	TMC can be used for international comparisons of per capita global resource consumption of countries.
	does not explicitly indicate specific environmental impacts			
Concept	ew-MFA; socio-industrial metabolism			
Method	Eurostat Guide 2001			
	Eurostat/OECD Implementation Guide		WI / ISTAT / BFS / ONS	WI / SERI / GWS
	Eurostat Task Force			
	SNA compatible			

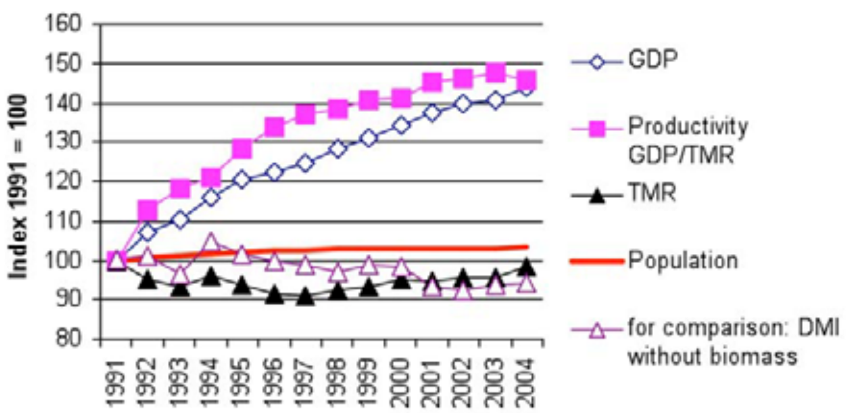
Practical application

	DMI	DMC	TMR	TMC
International	Eurostat EU27 data set (plus NO, CH)			
	OECD for member countries			
	NSI eg in AT, CZ, DK, FI, FR, DE, HU, IT, ES, SE, CH, UK		NSI in DK, FI, FR, IT, ES, CH, UK	NSI in DK, FI, FR, IT, ES
	Institutes like WI, IFF		WI / SERI	WI / SERI
National	Destatis annually from 1994 - 2007		WI for Germany 1991-2004	WI for Germany 1991-2004
Effort for compilation	best case 3 to 4 PM first compilation		best case 5 to 6 PM first compilation; specific IF study may add up to 6 to 12 months	
	1 to 2 PM for update		3 to 4 PM for update	
Data availability	Eurostat NewCronos and OECD for free; low degree of detail			
	Destatis for free, medium degree of detail		NSI for free, low to medium degree of detail	
	Own compilation from international data sources requires skills for eg standardisation and plausibility checks for biomass and construction minerals		requires specific data depending on chosen method (eg statistics for unused extraction, coefficients and/or IO for indirect flows)	

The presentation

- Definition, Objectives, Foundations
- Practical application
- **Some old and some new results**
- Policy relevance
- Development requirements and perspectives

Total resource productivity in Germany



Source: Schütz and Bringezu 2008

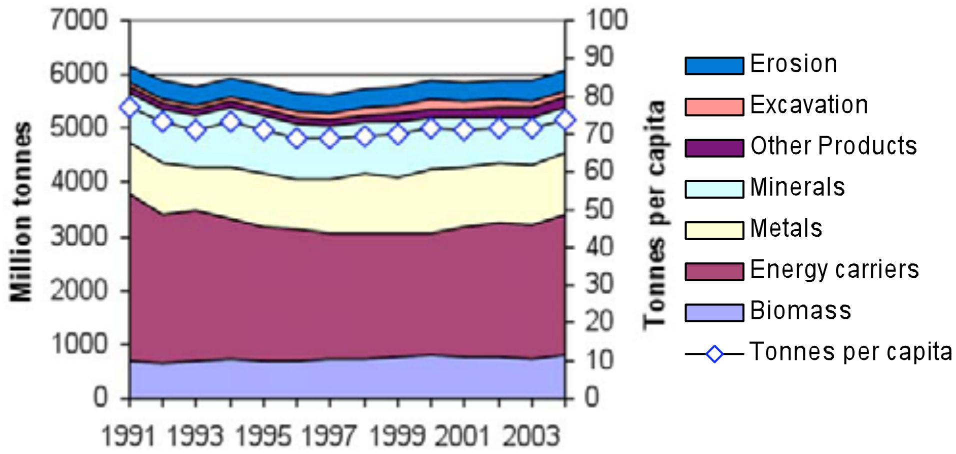
In comparison to GDP, which exhibits continuous rise from 1991 to 2004, TMR showed first a decline from 1991 to 1996 and thus a tendency for absolute decoupling. After 1996 the TMR rose however until 2004.

Over the entire period rather a relative decoupling of the global total material requirement from economic growth took place.

The productivity of the TMR amounted in 2004 to approx. 0.36 Euro per kg, which was only approx. 28% of the DMI productivity. The relative rises of both productivities during the entire period were however similar with 46% increase from 1991 to 2004.

The raw material indicator (DMI – biomass) shows no decline over the early 1990s but goes down to similar level as TMR during 2001-2004 vs 1991.

Total Material Requirement (TMR) of the German economy



Energy carriers dominate TMR, particularly because of domestic used and unused extraction.

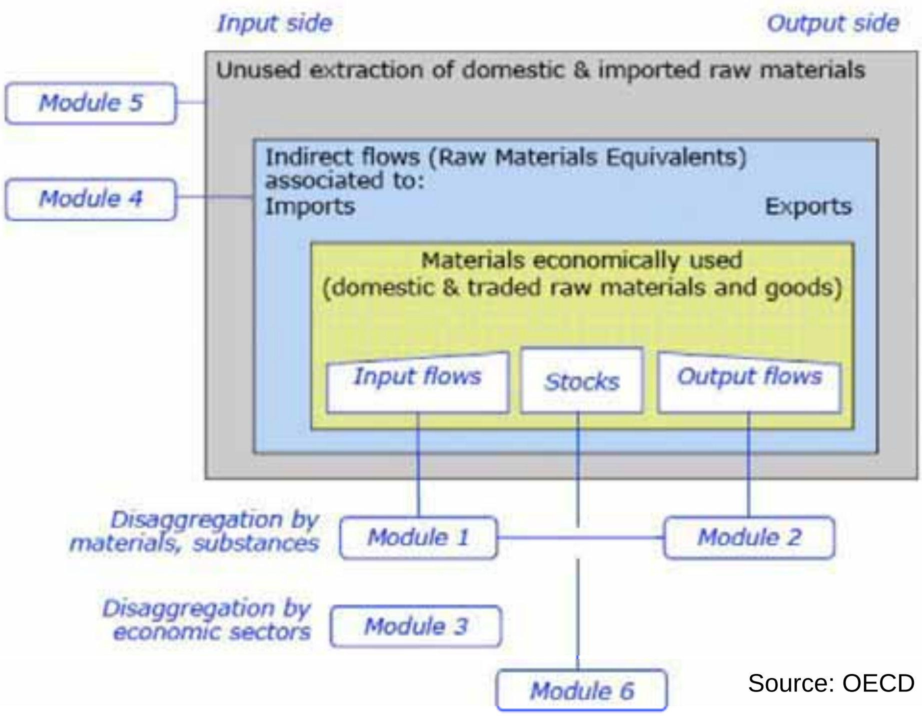
Metals and minerals are the next important components mainly due to high IF of imports for metals and high domestic extraction of construction minerals.

Biomass makes an only little lower contribution. The erosion is scarcely half of the TMR for biomass.

Excavation and other products have only relatively small portions of the TMR.

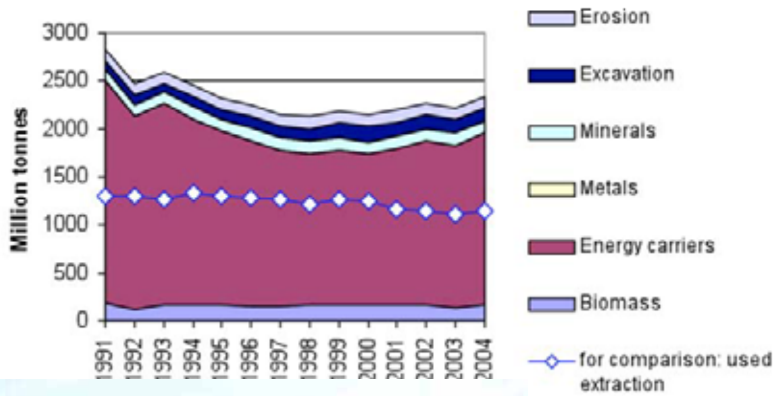
Source: Schütz and Bringezu 2008

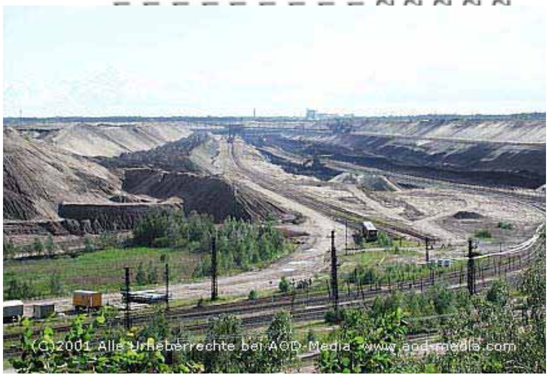
TMR comprises all flows of the input side – with Indirect flows of imports comprising RME plus foreign Unused Extraction as an aggregate



Source: OECD 2008

Unused extraction within Germany





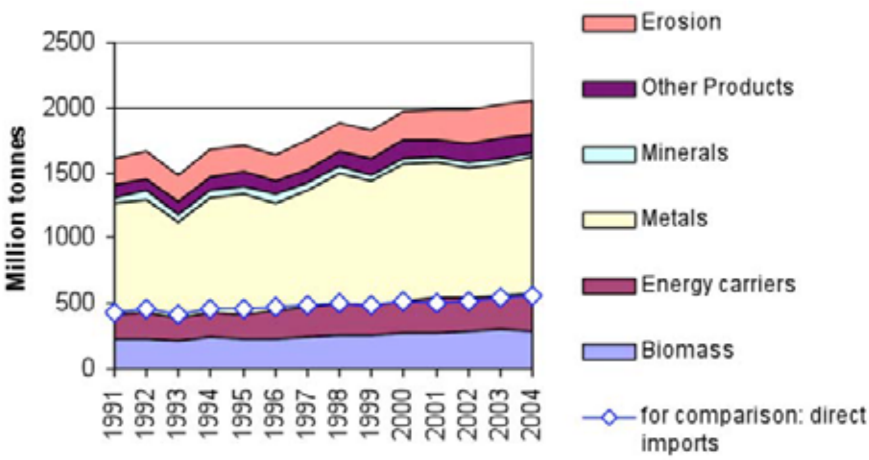
The unused domestic extraction (UDE) is roughly 2 times that of used extraction in Germany - and determined to a large extent by the extraction of energy carriers. Among them dominates the overburden of brown coal production, being responsible alone for 80% to 75% of total UDE.

From 1991 to 1998, the extraction of unused primary materials from the environment declined. However a slight rise was to be registered from 1998 to 2004.

The ratio of unused extraction to used extraction of energy carriers increased over 1991 to 2004 indicating increasing inefficiency of the raw material extraction of fossil energy carriers, above all that of brown coal.

Source: Schütz and Bringezu 2008

Indirect resource flows of German imports



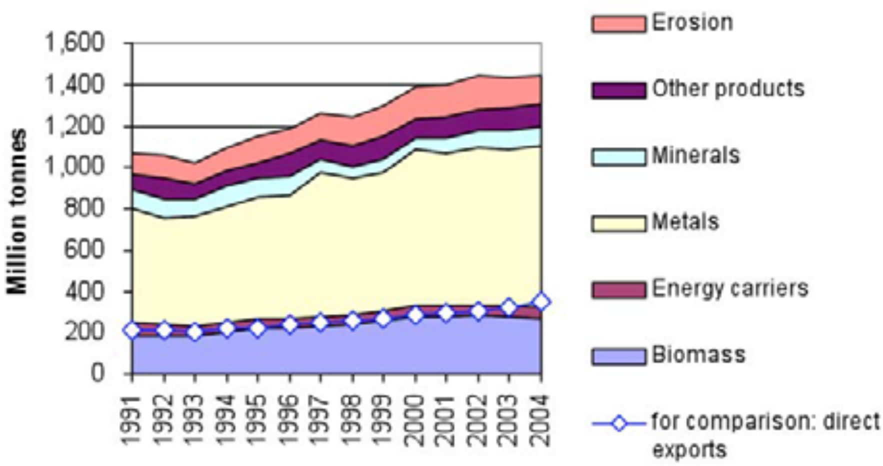
Indirect resource flows of imports make up almost four times the amount of direct imports.

Differently than with the direct imported goods, with which energy carriers dominated, the indirect flow of materials is predominantly due to metals of different kinds and manufacturing depths (above all iron ores, iron and steel, copper ores and - concentrates, tin, aluminium and machinery).

This is above all because of the fact that metallic goods (with exception of iron ores and bauxite) are traded mostly in highly concentrated respectively finished state, so that large quantities of extraction-, concentration- and processing-wastes remain in the country of origin, and thus contribute to the indirect flow of metals.

Source: Schütz and Bringezu 2008

Indirect resource flows of German exports



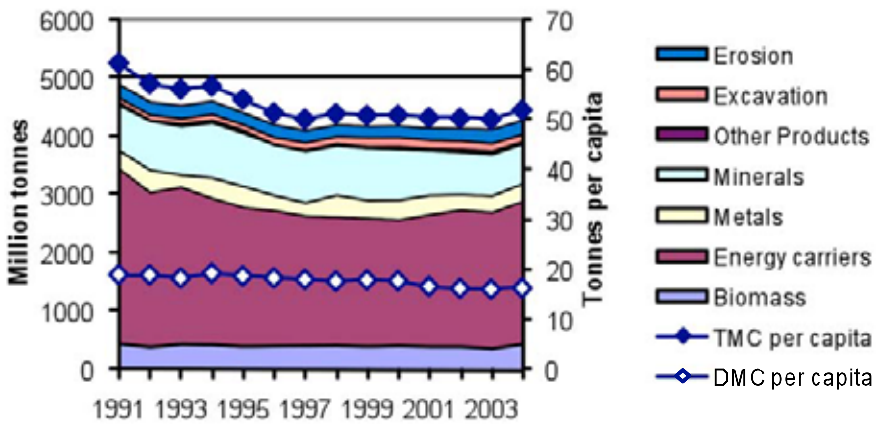
Indirect resource flows of exports make up four to five times the amount of direct exports.

Differently than with the direct exports, but as with the indirect flow of material of imported goods, the flow of indirect material caused by exported metals of different kinds and manufacturing depths dominate the total indirect flows of exported goods (above all iron and steel, copper metal goods and machinery).

This was above all because of the fact that increasingly metallic goods of higher manufacturing depth went into the export, so that an increasing portion of the rising imports of metallic goods was not intended for domestic consumption, but for the consumption of the rest of the world

Source: Schütz and Bringezu 2008

Total Material Consumption (TMC) of the German economy



With the TMC, as particularly with the TMR, energy carriers dominate because of the high domestic extraction, which is intended for domestic consumption predominantly (above all brown coal for the generation of electricity, with used and unused extractions).

Also mineral materials have a relatively high portion of the TMC, particularly because of their main use as building materials.

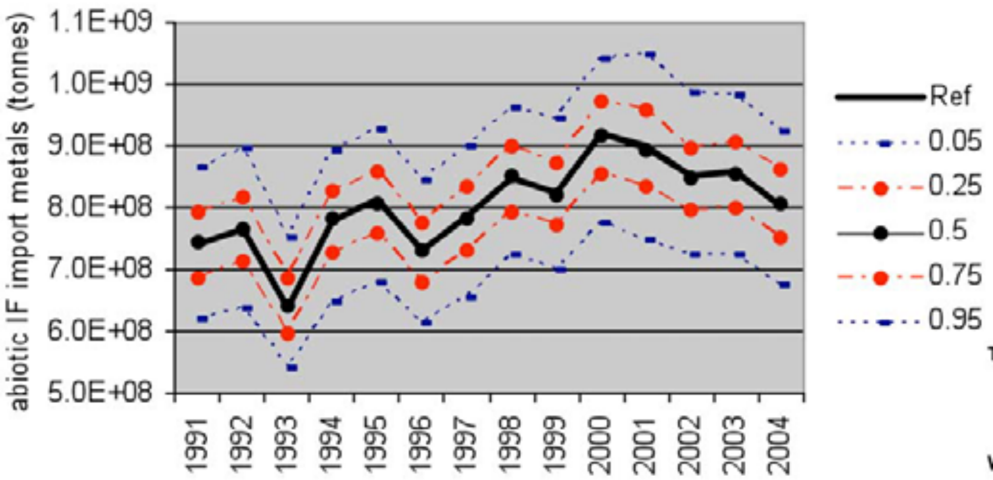
In comparison to the TMR, metals have a relatively small portion of the TMC. This is because of the high „throughput" of metals by the foreign trade.

Per capita, the TMC of 61 tons in 1991 declined to 52 tons in 2004. It was in 2004 around 3 times higher than the DMC.

The direct materials consumption indicates therefore only a smaller part of the entire materials consumption by the German economy.

Source: Schütz and Bringezu 2008

Sensitivity analysis for IF of imported metals to Germany 1991 - 2004



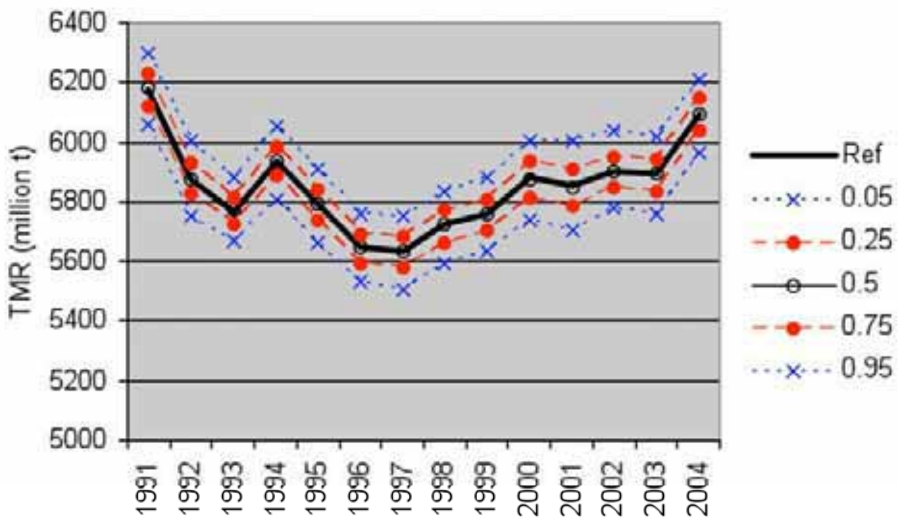
Probability distributions of abiotic IF of imported metals were based on expert judgement of the range of IF coefficients for metals, and done by Monte Carlo simulation over the probability distributions of the IF coefficients (1000 samples) from which the total IF was calculated.

The figure presents the reference value and different percentiles.

With 90% probability the TMR for metals lies in between ± 15% of the reference value.

Source: Saurat, M., Schütz, H., Bringezu, S. (WI)

Sensitivity analysis for TMR of Germany 1991 – 2004



Based on the above probability distributions of abiotic IF of imported metals, the result for the entire TMR of Germany was calculated.

The figure presents the reference value and different percentiles.

With 90% probability the TMR of Germany lies in between ± 2% of the reference value.

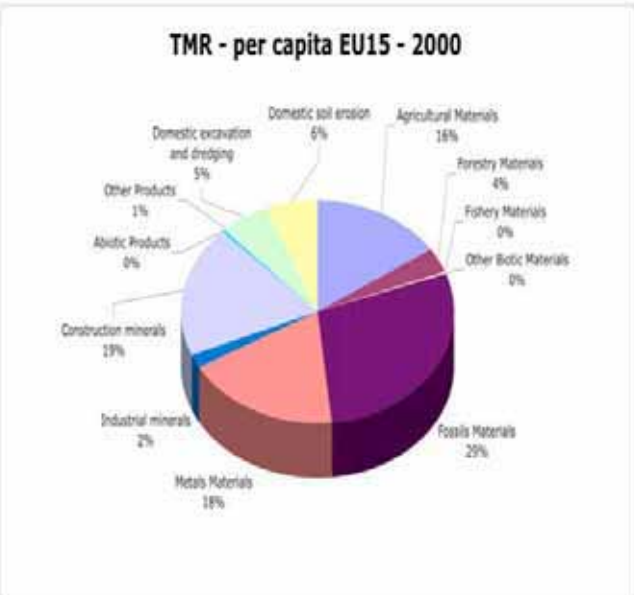
Source: Saurat, M., Schütz, H., Bringezu, S. (WI)

Policy relevance

	DMI	DMC	TMR	TMC
Measure	GDP/DMI can measure (direct) material productivity (OECD 2008)	GDP/DMC is used to express "resource productivity" (eg Eurostat 2009)	GDP/TMR measures total resource productivity of a country (OECD 2008).	GDP/TMC is proposed to express "resource productivity" (eg Eurostat 2009)
Rationale	DMI includes exports which contribute significantly to GDP	DMC taken as counterpart to GDP	TMR represents the most comprehensive resource use indicator for the physical basis of an economy that generates its wealth (GDP) from global resources, while providing goods and services for domestic final consumption and exports.	TMC taken as counterpart to GDP
Policy use	Japanese government Fundamental Plan for Establishing a Sound Material-Cycle Society	EC headline indicator for "resource productivity" expressed as GDP/DMC	TMR target in Environmental Action Plan for sustainable development in Italy ; Monitoring indicator Japan	TMC has been proposed by EC to replace DMC as denominator (GDP/TMC) for the headline indicator "Resource productivity"

TMR allows to set priorities for resource productivity enhancement in industry

Components of TMR EU-15



	Economic Branches
1	**Construction**
2	Food products and beverages
3	**Basic Metals and fabricated metal products**
4	Electricity, gas, steam, hot water supply
5	**Motor vehicles, trailers and semi- trailers**
6	Chemicals and chemical products
7	Machinery and equipment
8	Coal and lignite, peat
9	Agriculture, hunting
10	Coke, refined petroleum products, nuclear fuel

Results of IO-analysis: direct and indirect TMR of products delivered to final demand.

Development requirements and perspectives

	DMI	DMC	TMR	TMC
Development Requirements	Full harmonisation of methodology and data with SNA/SEEA		full harmonisation of methodology and the provision of reference data across countries	
	Fully standardised data acquisition across countries		NSI are expected to account for domestic unused extraction after having established DMI/DMC, also to provide sufficient information on waste flows.	
Perspectives	Combined efforts undertaken by Eurostat, OECD, UN and experts		For the consideration of indirect flows of imports, to reach a similar level of accuracy like in Germany, NSI would need assistance in the form of a data base with coefficients for internationally traded products	A future best available method will thus likely combine the coefficient approach for a selected number of raw materials and semi-manufactured products with an IO approach for higher-manufactured products (where the IO approach should apply a multi-regional IO-MFA model)

Wuppertal Institute
for Climate, Environment
and Energy

Many thanks for your attention !

helmut.schuetz@wupperinst.org

DMI and DMC of Germany calculated as Raw Material Equivalents

Šárka Buyny

Workshop Material Use Indicators for Measuring Resource Productivity and Environmental Impacts
Berlin, 25. - 26. 2. 2010

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- **What? Why? and How?**
- **Results**
- **Evaluation and improvement potential**

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- **What? Why? and How?**
- **Results**
- **Evaluation and improvement potential**

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Raw material equivalents

- WHAT?

Used extraction which was needed to produce the traded goods

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Raw material equivalents

- WHY?

Improvement of the indicator
"raw material productivity"

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Raw material productivity

GDP / DMI

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Raw material productivity *

GDP / $DMI_{abiotic}$

How many units of gross domestic product (in €) are produced by one unit of abiotic primary material (in tons)

* According to National Strategy for Sustainable Development

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Raw material productivity

- HOW?

abiotic domestic extraction

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Raw material productivity

- DMIa

abiotic domestic extraction

imported raw materials and products (abiotic)

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Raw material productivity

- DMIa

abiotic domestic extraction

imported raw materials and products (abiotic)

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Raw material equivalents

- WHY?

Improvement of the indicator
“raw material productivity”

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Raw material equivalents

- WHY?

Improvement of the indicator
“raw material productivity”

- HOW?

Combination of input-output-analysis
and life-cycle-analysis

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Raw material equivalents

- HOW?

IOA

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Raw material equivalents

- HOW?

IOA
+ extensions

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Raw material equivalents

- HOW?

IOA
hybrid approach

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Raw material equivalents

- HOW?

IOA
hybrid approach

LCA
“special” products,
“foreign” products

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Raw material equivalents

- HOW?

IOA
hybrid approach

LCA
“special” products,
“foreign” products

LCA
transport

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Raw material equivalents

- HOW?

type of good

type of transport

transported tons

type of fossil fuel

distance

other determinants

LCA
transport

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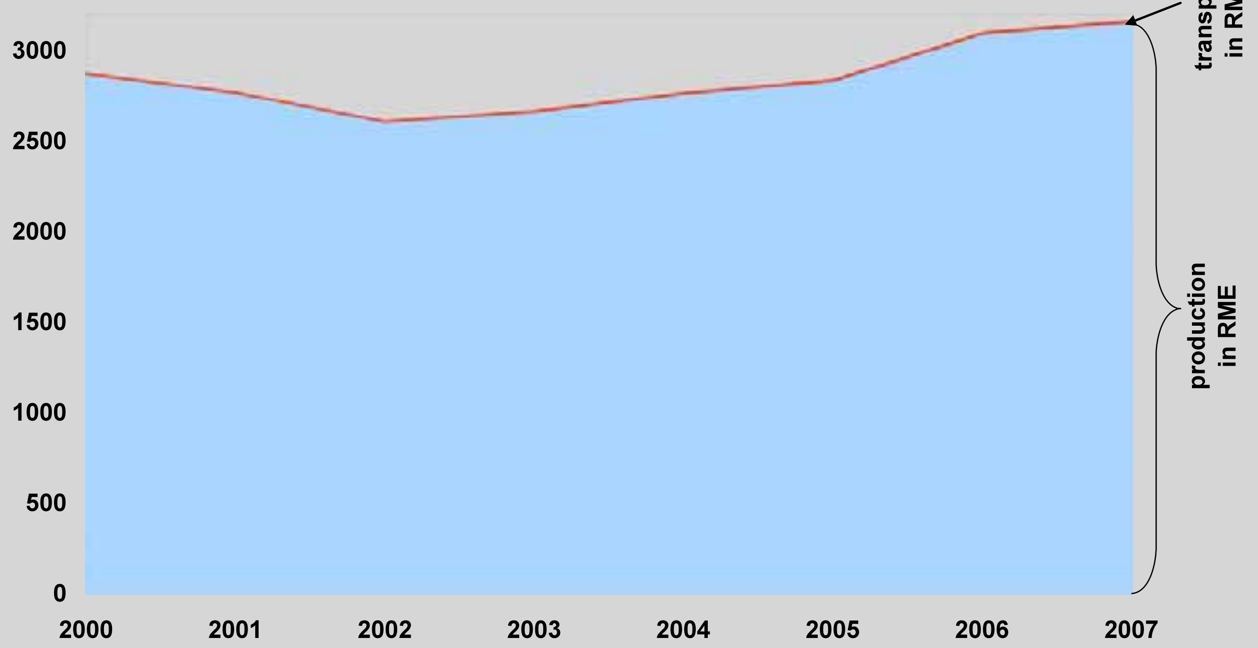
Imports in RME

in million tons



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- What? Why? and How?
- **Results**
- Evaluation and improvement potential

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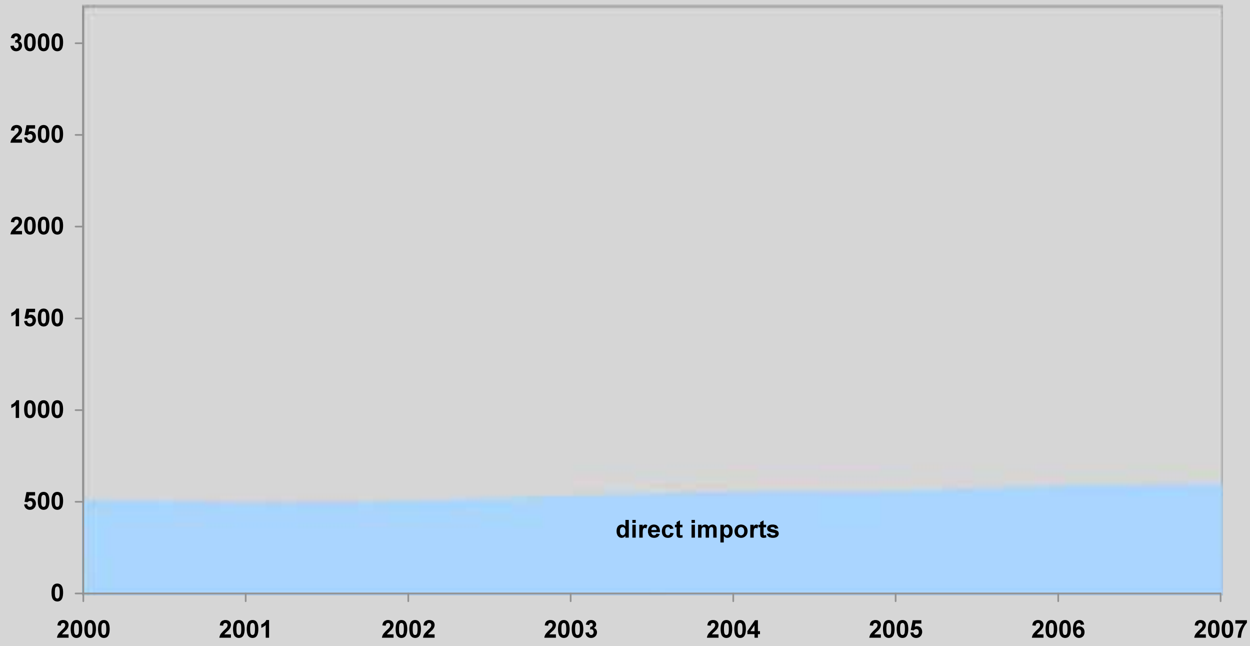
Imports in RME
in million tons



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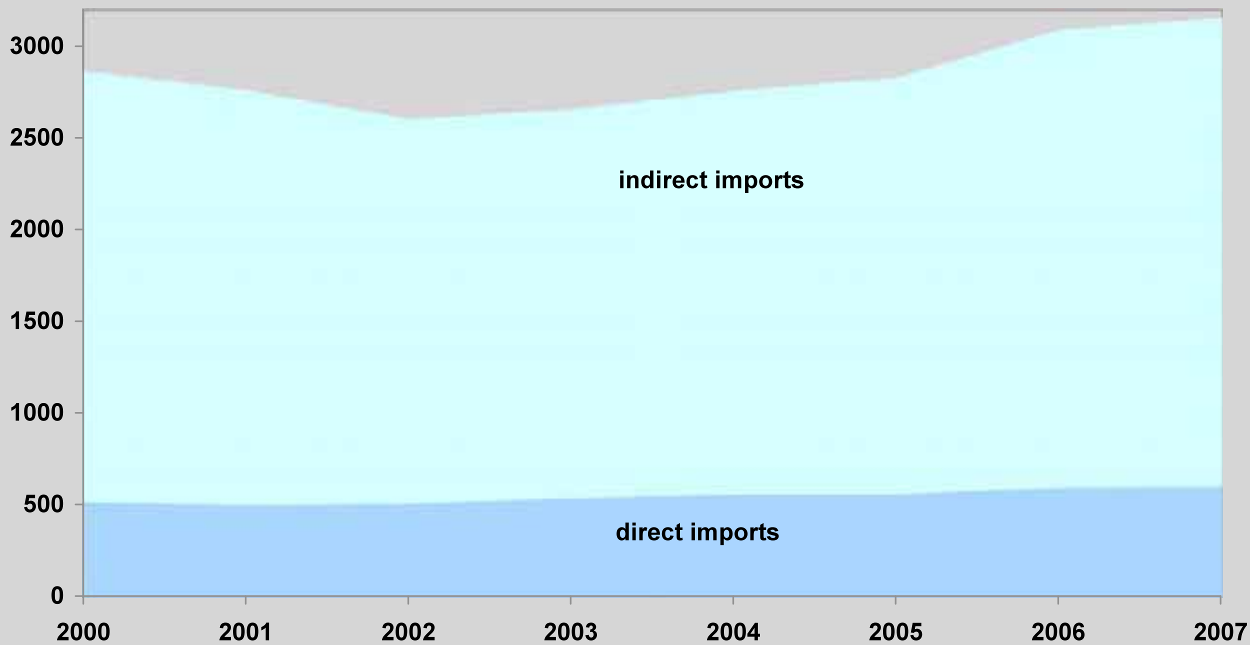
Imports in RME
in million tons



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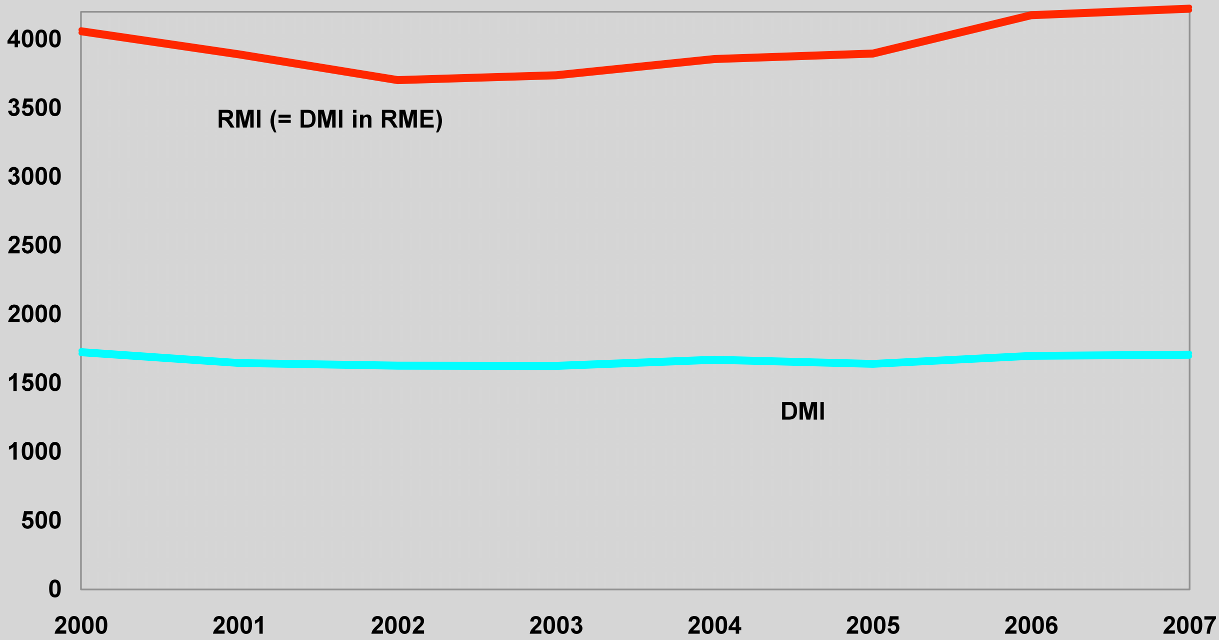
RMI vs. DMI

in million tons



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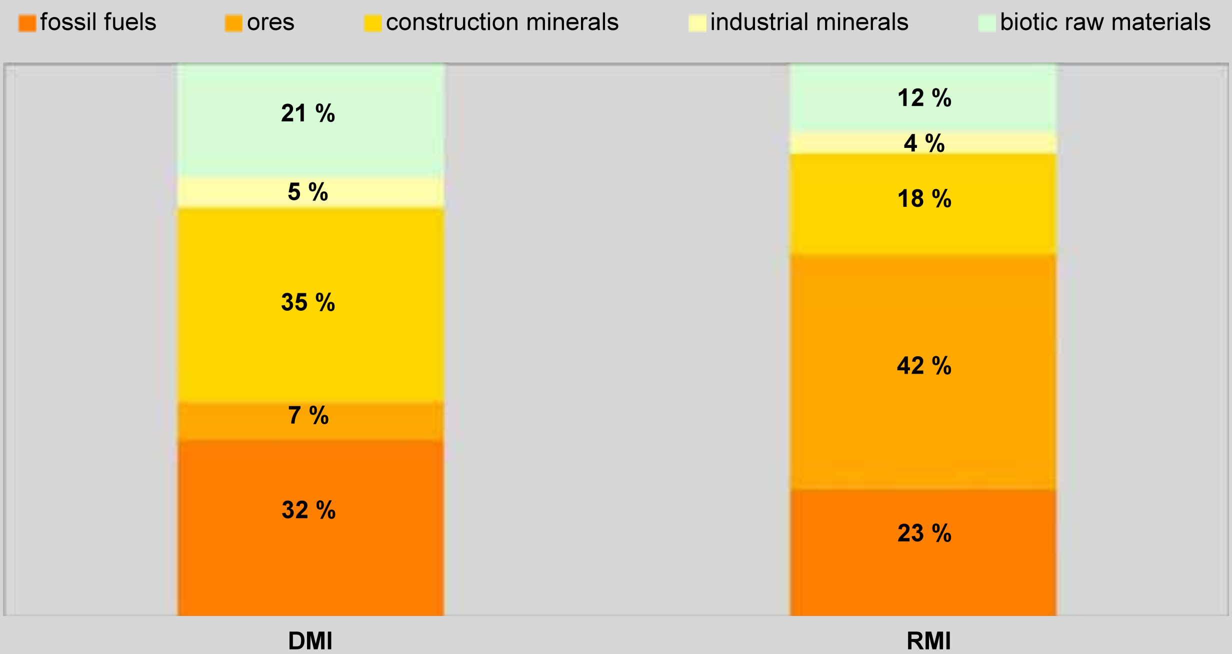
DMI and RMI - by raw material groups

2005, in %



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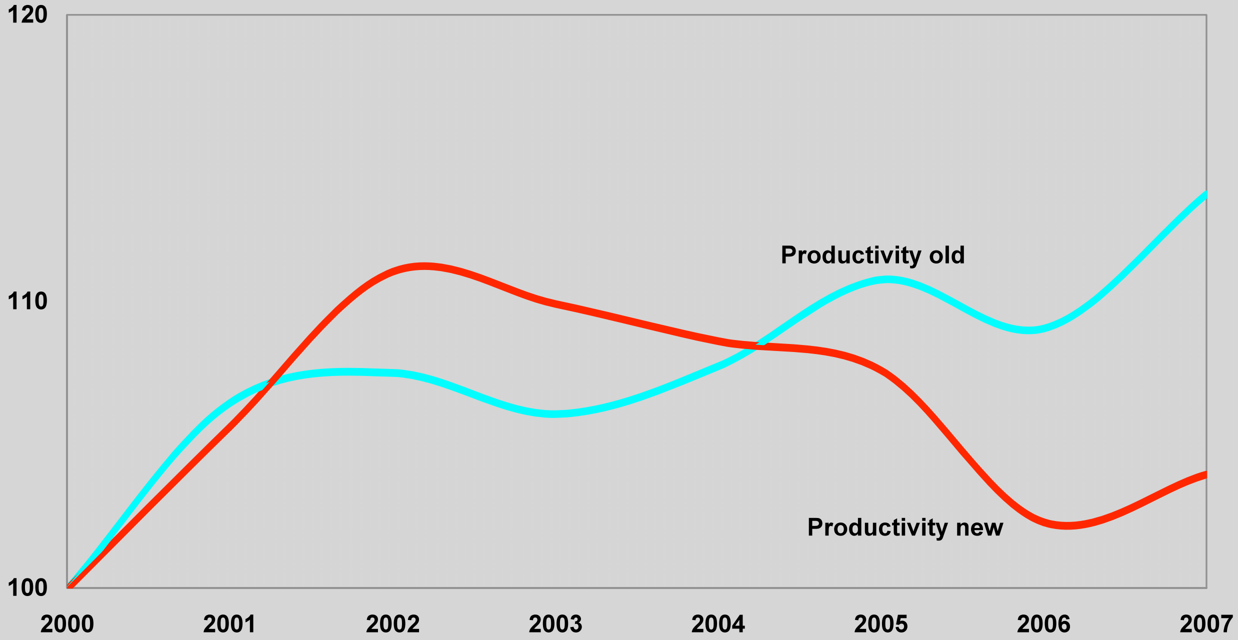
DESTATIS wissen.nutzen.

Raw material productivity (based on $DMI_{abiotic}$)

2000 = 100



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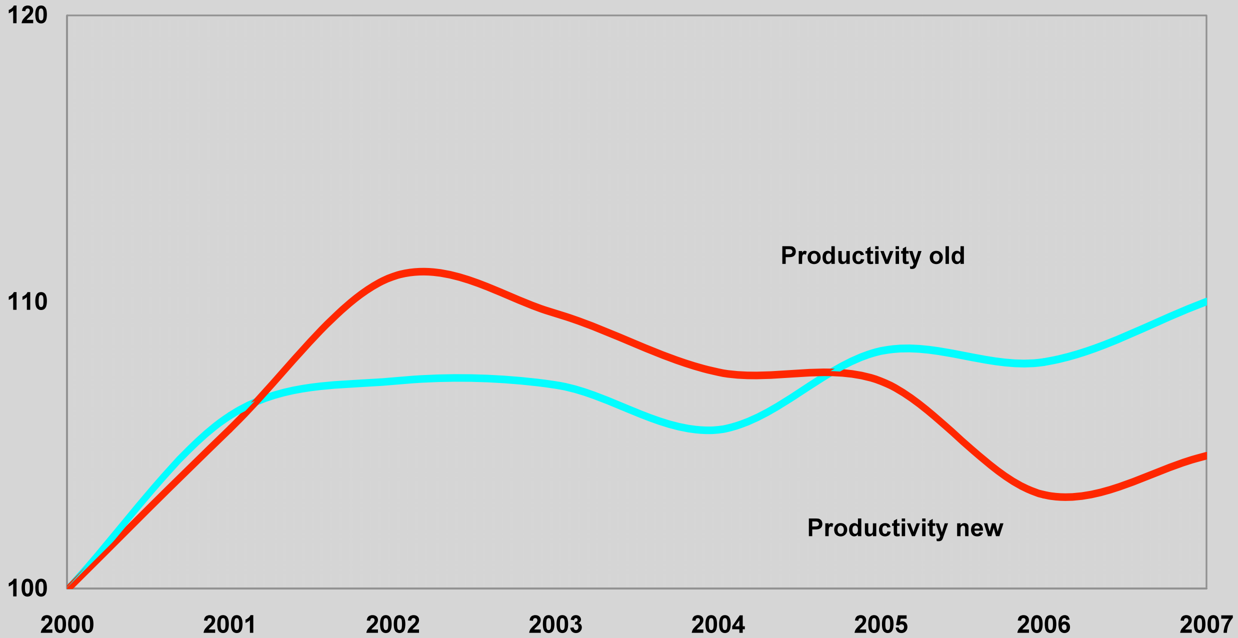
Raw material productivity (based on $DMI_{abiotic+biotic}$)

2000 = 100



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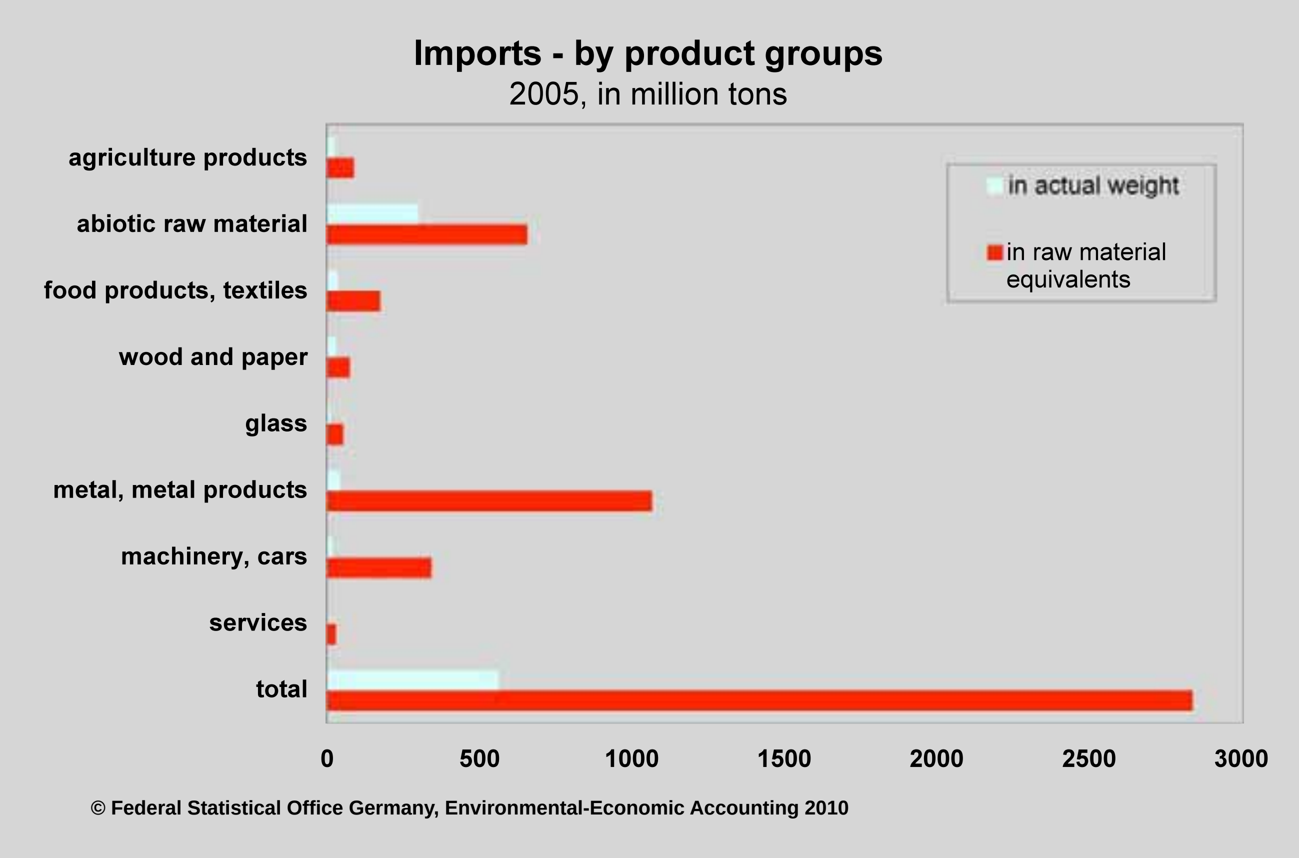

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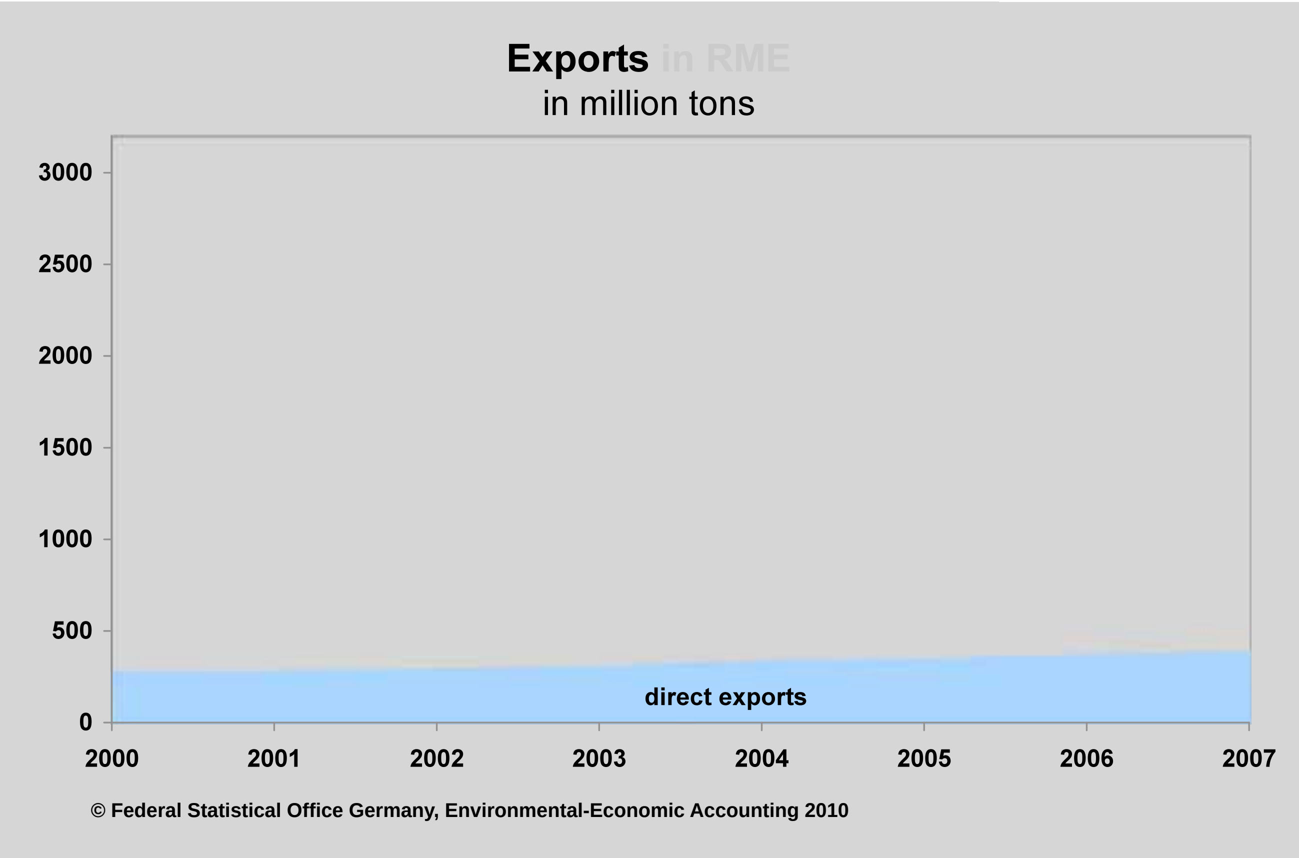

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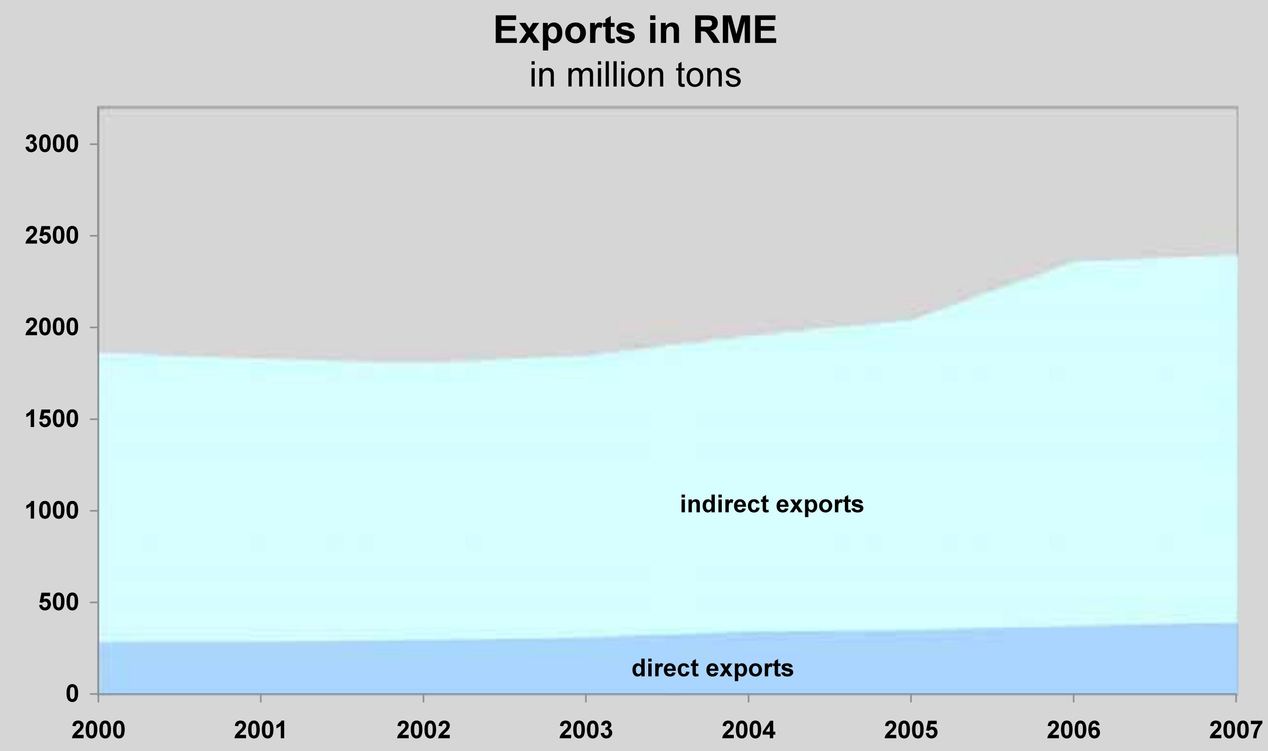

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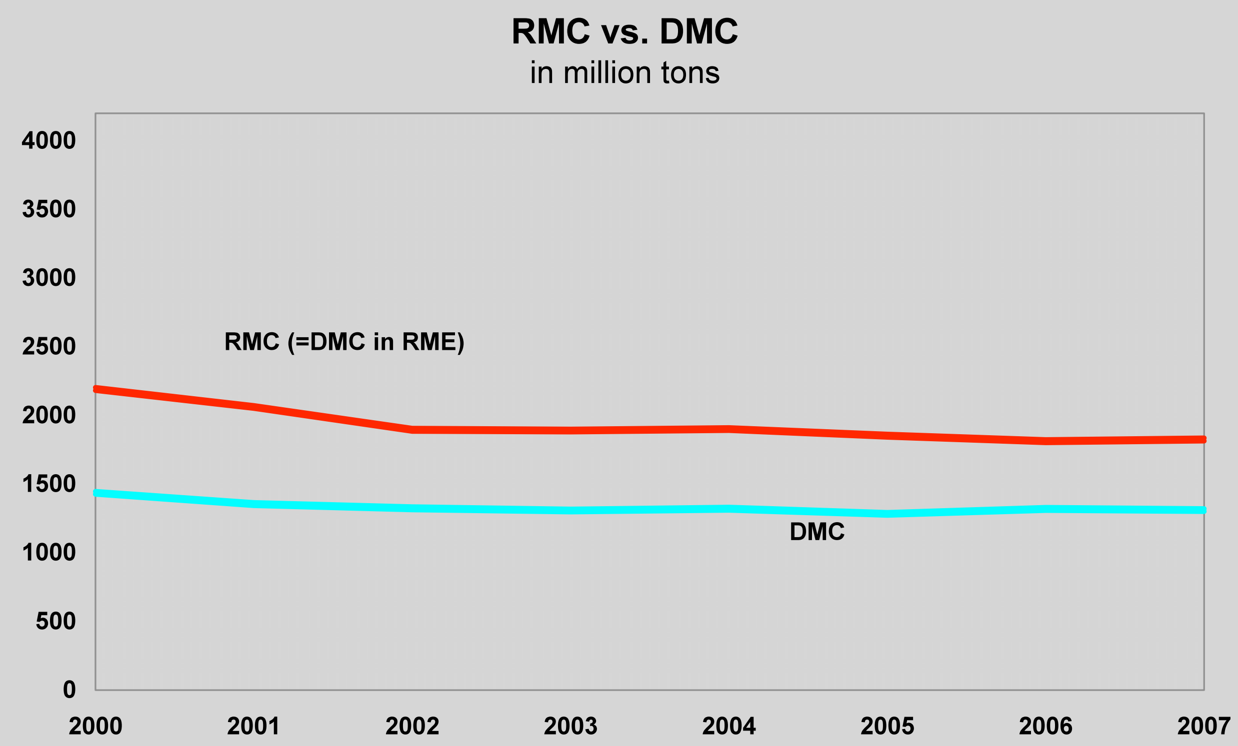

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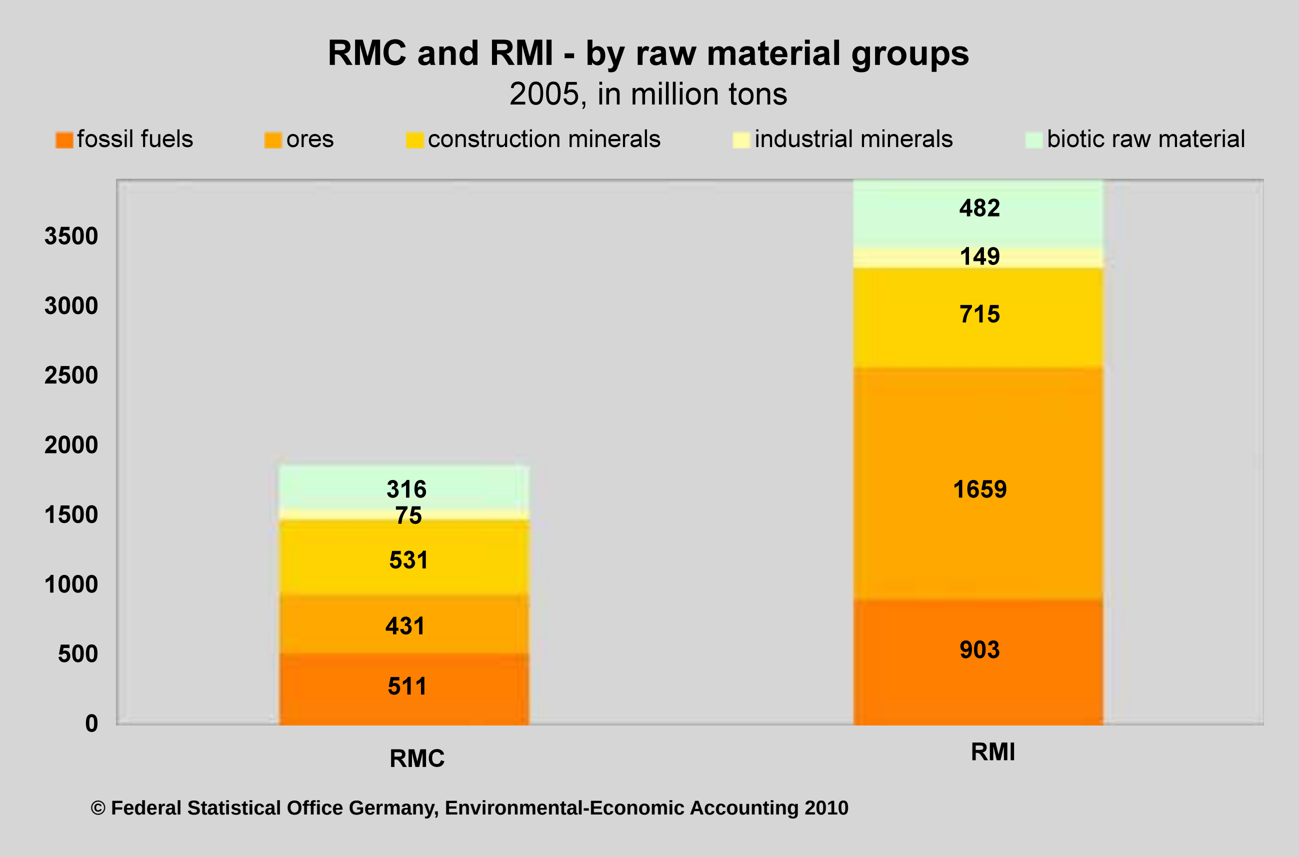

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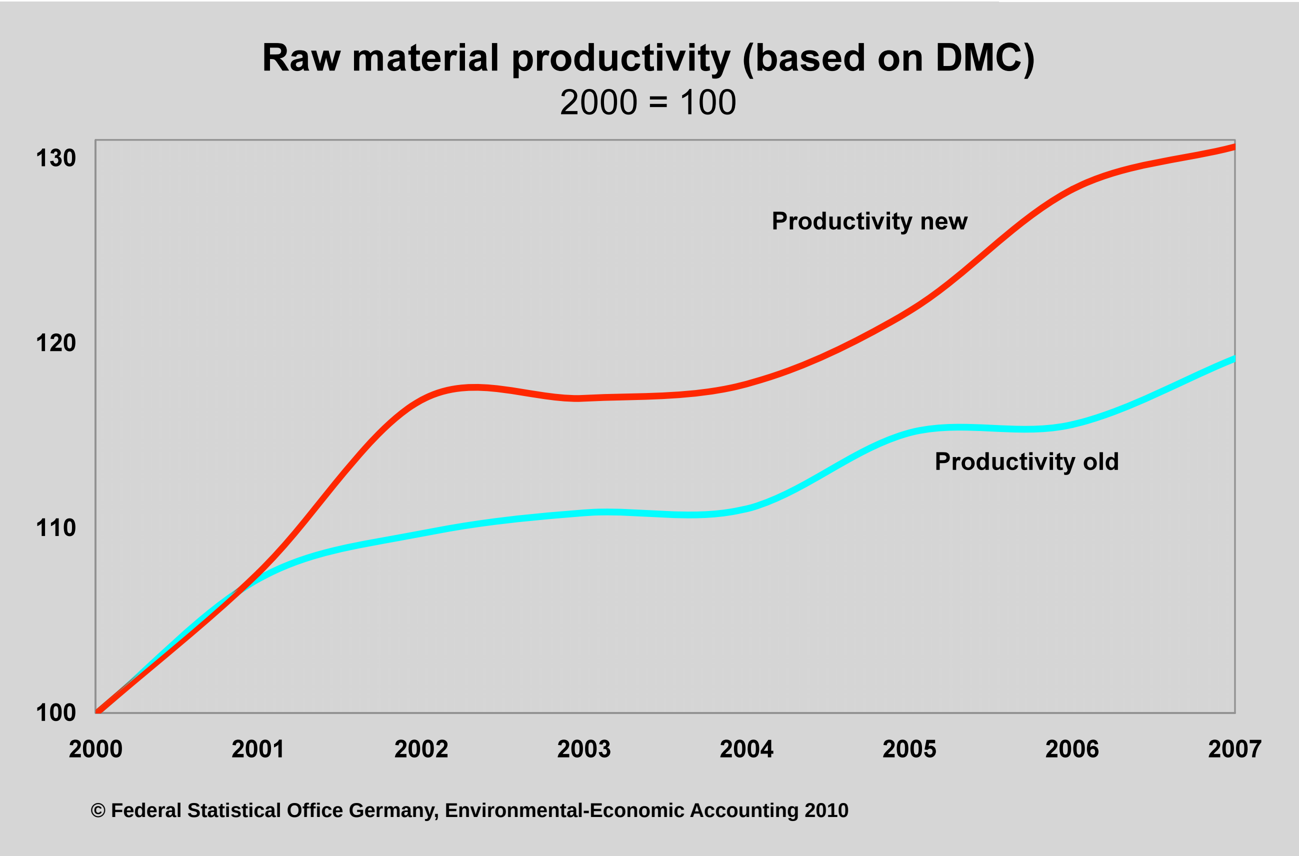

- What? Why? and How?
- Results
- **Evaluation and improvement potential**

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Evaluation and improvement potentials (1)

- Hybrid approach
- **German** input-output-tables
- Consideration of the production conditions in import countries (energy mix, import coefficients)
- Constant import coefficients for the whole time series
- Quality of import coefficients
- Aggregation problem of some raw material groups

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Evaluation and improvement potentials (2)

- Capital formation
- Waste and scrap (metal and wood)
- Recycling of glass and plastic: not included

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Thank you for your attention.

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Accounting for Environmental Impacts of Resource Use

Outline of a challenge and recent approaches

Dr. Stefan Bringezu

Member of the International
Panel for Sustainable Resource
Management

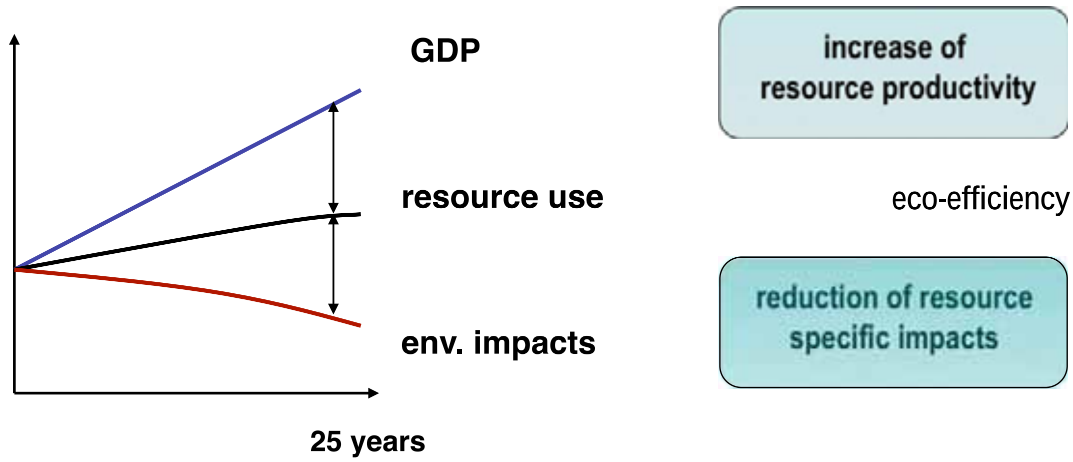
Director
Material Flows and Resource
Management
Wuppertal Institute

Presentation
Workshop "Material Use
Indicators for Measuring
Resource Productivity and
Environmental Impacts"
26 Feb 2010
Berlin

The presentation

- The goal of double de-coupling
- Basic challenges of impact assessment
  - System definition
  - Characterisation and quantification of impacts
  - Normalization and weighting of single impacts
  - Weighting between different impacts
- Conclusions

Objectives of the EU resource strategy



⇒ How to effectively decouple resource use from economic growth?
⇒ Is it possible to decouple environmental impacts from resource use (at macro level)?

Observations

- Materials and products are associated with **different environmental profiles** which add up to the overall performance of the economy in a way that strengths and weaknesses across production lines **often compensate** each other
- **Substitution** of one material for another also leads to the **exchange of the related bundles** of specific pressures
- **Shifts between** different environmental **impacts** may not be easy to evaluate (GHG vs. waste or vs. eutrophication)
- Shifts **towards impacts which cannot be measured** sufficiently will be neglected (-> problem shifting ?!)

Basic challenges

- **Systems definition** and the inventory of the materials and resources
- **Characterization and quantification** of specific environmental impacts
- **Normalization** of each impact to compare it with other impacts
- Relative **weighting of different impacts** against each other

System definition

- **"life-cycle-wide": cycle of what?**
- **interlinked flows of resources, materials or products along extraction-production-consumption-recycling-disposal**
- **3 basic approaches:**
  - Selection of materials or/and products (bottom-up LCA)
  - comprehensive product group approach (top-down Input-Output)
  - hybrid (IOA + LCAI and macro + LCAI)

System definition
Selection of materials or products (bottom-up LCA)

- **Selection requires priority setting**
  - e.g. particularly critical base materials,
  - e.g. product groups of environmental relevance

- **Specification determines results**
  - e.g. "cereals" vs. "wheat, maize, sugar cane..."
  - e.g. "PGM" vs. "PGM from South Africa, Russia, ..."
  - e.g. "cars" vs. "Golf A4, Mercedes S, ..."

System definition
Input-output approaches – comprehensive product groups

- **Total economy covered, but so far only limited number of broad product groups and limited availability of impact data**

- **Import related impacts often calculated based on assumption of domestic technologies**

- **NAMEA: available[1] for EU8/9, EU-25 (ETC-SCP, Eurostat)**
  60 sectors, GWP, ACID, TOFP, DMI, TMR[2]

[1] until end of 2010
[2] pilot country(ies)

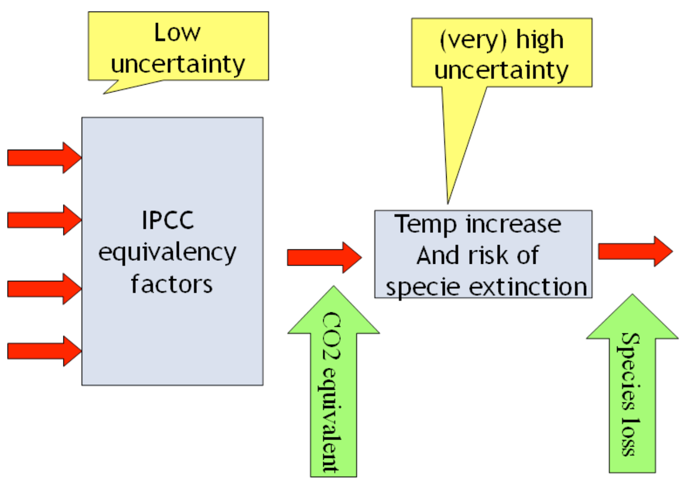
- **EXIOPOL: under development in FP6**
  129 sectors, EU-27countries+16countries+RoW
  energy, material, land use, emissions as far as available
  would allow comprehensive analyses when completed

System definition
Hybrid approaches

- **For single pressure indicators such as TMR (similar to material use indicator RME by Destatis): combination of LCAI and IOA can be used to account for import related flows**
- **New project: Macro LCA indicators**
  (PE-International and WI for JRC-Ispra)
  - impacts of resource use
    all domestic impacts available (macro) and all import and export LCIA impacts available (micro)
  - impacts of product consumption
  - impacts of waste managment

Characterization and quantification of impacts
What is an impact and how certain is it ?

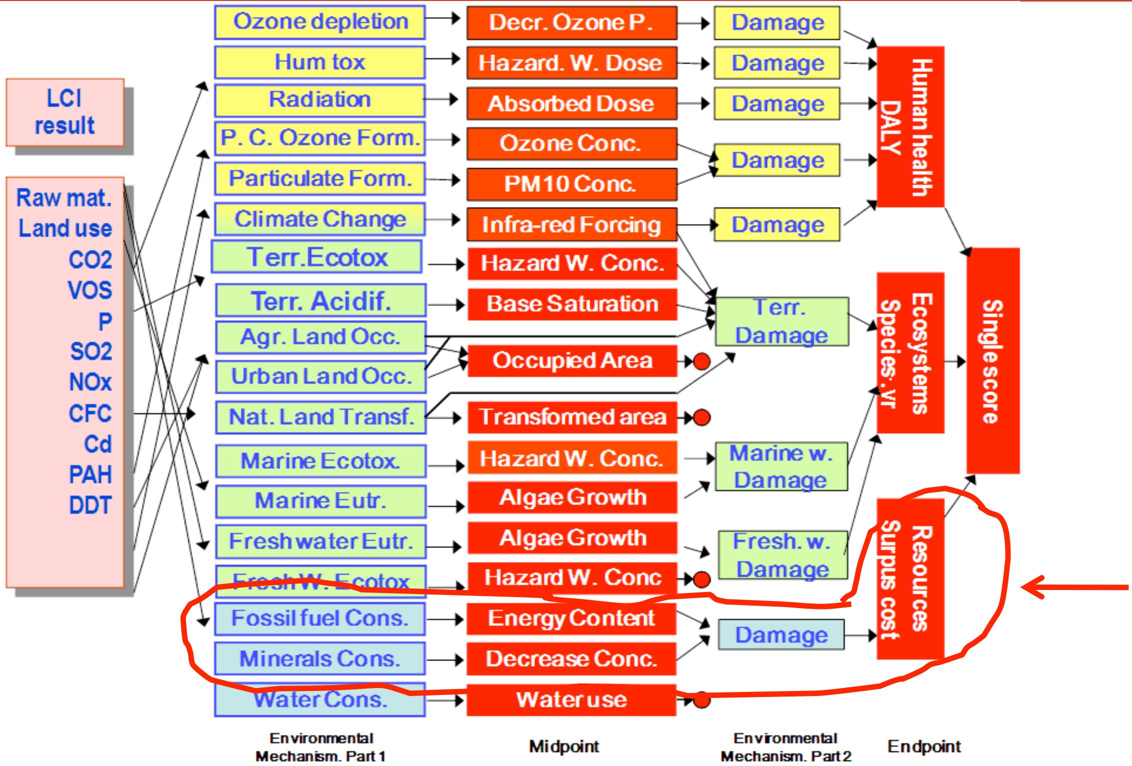
- **"mid points" (= pressure indicators in DPSIR)**
  e.g. GWP, ODP, eutroph. potential, acidif. pot. etc
- **"end points"**
  e.g.
  - Species loss
  - Deaths
  - Resource depletion



➢ **midpoint indicators have higher certainty**

Source: http://www.lcia-recipe.net/

Characterization and quantification of impacts
The example of ReCiPe (EcoIndicator 99)



Example: characterization of Resource Depletion
"Damage to resources" EcoIndicator 99

- only for minerals (non-bulky) and fossil fuels
- decrease in "quality" of resources for extraction
  - concentration for minerals (metals)
  - effort of extraction for fossil fuels
- measured as "surplus energy" (Müller-Wenk 1998): difference between energy for exraction now and some time in future

Egalitarian (all in MJ per extracted MJ)	conventional energy use (MJ/MJ)	To be replaced by	Extraction energy (MJ/MJ)	surplus energy MJ/MJ
1. Conventional natural gas	0.010	coal shale mix	0.099	0.089
2. Conventional oil, average extraction 1990	0.016	coal shale mix	0.099	0.083
3. Hard coal, open pit mining	0.017	coal shale mix	0.099	0.082
4. Crude oil, secondary extraction	0.023	coal shale mix	0.099	0.076
5. Hard coal, underground mining	0.034	coal shale mix	0.099	0.065
6. Brown coal, open pit mining	0.038	coal shale mix	0.099	0.061
7. Crude oil, tertiary extraction	0.110	crude oil tert. pr.	0.11	0.000
8. Crude oil from oil shale	0.160	oil shale	0.16	0.000
9. Crude oil from tar sand	0.230	tar sand	0.23	0.000

Table 6.2: Surplus energy values (damage factors) for fossil fuels (Egalitarian)

Abiotic resource depletion potential (ADP) (Guinée et al. 2002)

- Element extraction rate per ultimate reserves in relation to antimony
- Energy carriers extraction rate per energy resources

$$ADP_i = \frac{DR_i}{(R_i)^2} \times \frac{(R_{ref})^2}{DR_{ref}} \quad (1)$$

Where

ADP_i = Abiotic Depletion Potential of resource i (dimensionless)

R_i = Ultimate reserve of resource i (kg)

DR_i = Extraction rate of resource i ($kg.yr^{-1}$)

R_{ref} = Ultimate reserve of the reference resource, *viz.* antimony (kg)

DR_{ref} = Extraction rate of the reference resource ($kg.yr^{-1}$)

Characterization of resource depletion potential varies significantly between methods

Table 6: CML characterisation factors with antimony as the reference mineral

Mineral	Extraction (kg/yr)	Ultimate reserve (kg)	Characterisation factor
Antimony	6.06×10^7	4.63×10^{15}	1
Platinum	4.90×10^4	1.16×10^{14}	1.29
Iron	4.05×10^{11}	1.30×10^{21}	8.43×10^{-8}

Reserve values given by Gordon et al. (2006), Yale, for Platinum: 2.9×10^7 kg

- ➢ **Reference values (also for normalisation) critical**

Example of car exhaust system produced in South Africa

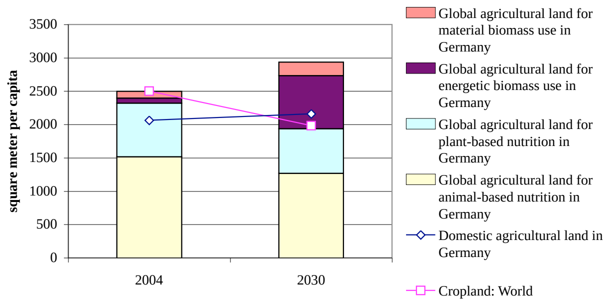
	Characterisation results		
Mineral	Modified SA procedure (kg platinum eq.)	CML (kg antimony eq.)	Eco-indicator 99 (MJ surplus energy)
Iron (from ore)	0.00565	0	0.916
PGMs (from ore)	0.01945	0.00838	462

- ➢ **Depending on the method results may vary over 5 orders of magnitude**

With kind permission from Springer Science+Business Media: Int J LCA 11(3), 2006, Characterisation and Normalisation Factors for Life Cycle Impact Assessment Mined Abiotic Resources Categories in South Africa: The manufacturing of catalytic converter exhaust systems as a case study (10 pp), pp. 162-171, Kerwin Strauss, Alan Brent and Sibbele Hietkamp, tab. 5+6

Characterization and quantification of impacts
Limitations of the LCA approach and alternatives

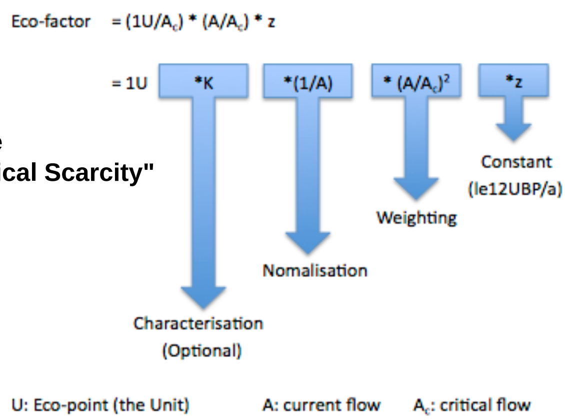
- **No harmonized LCA methods available e.g. on land use and land cover change, depletion of resource, esp. biotic resources (biodiversity)**
- **Bottom-up approach to consider land use change (LUC) difficult and highly uncertain – instead**
  - Global Land Use Accounting (GLUA), analogously to TMC, covers all land use for domestic consumption
  - quantifies overall LUC
    -> GHG emissions
    -> losses of biodiversity



Normalization and weighting of single impacts

- **Normalization relates the specific impact value to a reference value of the same impact, e.g.**
  - national, EU or global overall GWP
    (-> **specific contribution of a product**)
  - to a policy target (-> **distance-to-target**)
- **Resulting value has no unit ("Eco-point") and can be summed up across different impact categories**

Example "Ecological Scarcity"



Normalization of resource depletion potential varies significantly between methods

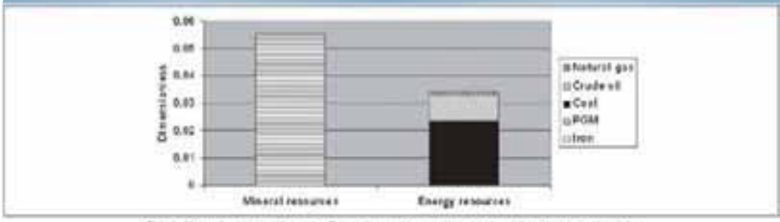


Fig. 5: Normalisation results of the Eco-indicator 99 procedure for the exhaust system life cycle

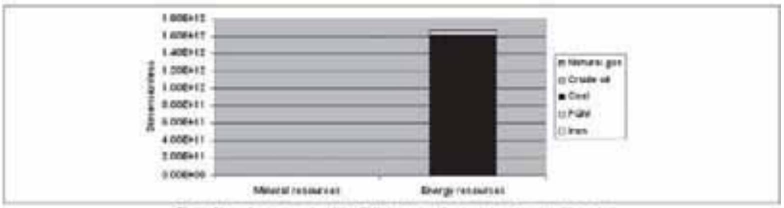


Fig. 6: Normalisation results of the CML procedure for the exhaust system life cycle

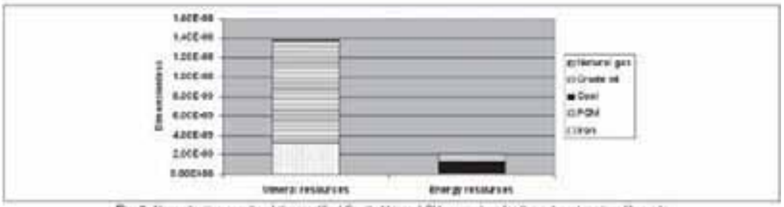


Fig. 7: Normalisation results of the modified South African LCIA procedure for the exhaust system life cycle

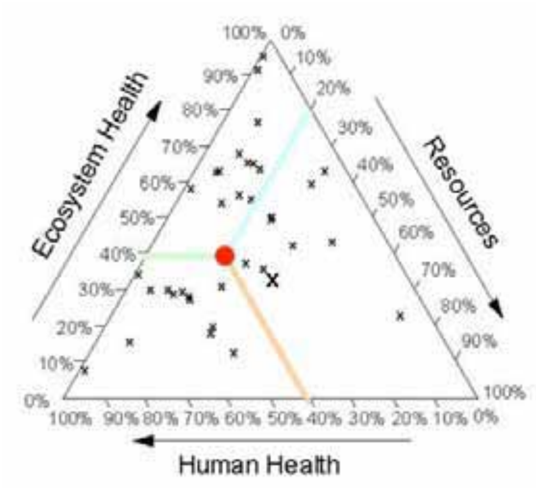
- CML method implicitely weighs energy carriers much more than minerals compared to Eco-indicator 99 and a region specific method

Example of car exhaust system produced in South Africa

With kind permission from Springer Science+Business Media: Int J LCA 11(3), 2006, Characterisation and Normalisation Factors for Life Cycle Impact Assessment Mined Abiotic Resources Categories in South Africa: The manufacturing of catalytic converter exhaust systems as a case study (10 pp), pp. 162-171, Strauss et al., fig. 7

Weighting between different impact categories

- **What is more important: health or environment, climate (GWP) or river quality (Eutroph.) or soils (acidif, waste) ?!**
- **Possibilities of weighting:**
  - equal weighting
  - using existing policy targets for normalization
  - asking a panel of selected persons



Source: http://www.pre.nl/eco-indicator99/weighting.htm

Conclusions

- Single impacts of overall resource use (production & consumption) such as GWP can be accounted with reliable certainty
- Accounting for various other specific impacts still difficult
  - characterization of important LCA impact categories still lacking or based on disputable assumptions
  - aggregation to single indexes requires additional normative assumptions
- Macro approaches in combination with reliable LCA elements seem promising to derive key indicators such as global land use (e.g. GLUA) and related change

Wuppertal Institute
for Climate, Environment
and Energy

Many thanks for your attention !

stefan.bringezu@wupperinst.org

Environmental weighting of resource use

Material Use Indicators for Measuring Resource Productivity and Environmental Impacts,

Berlin, 25-26 February 2010

Ester van der Voet

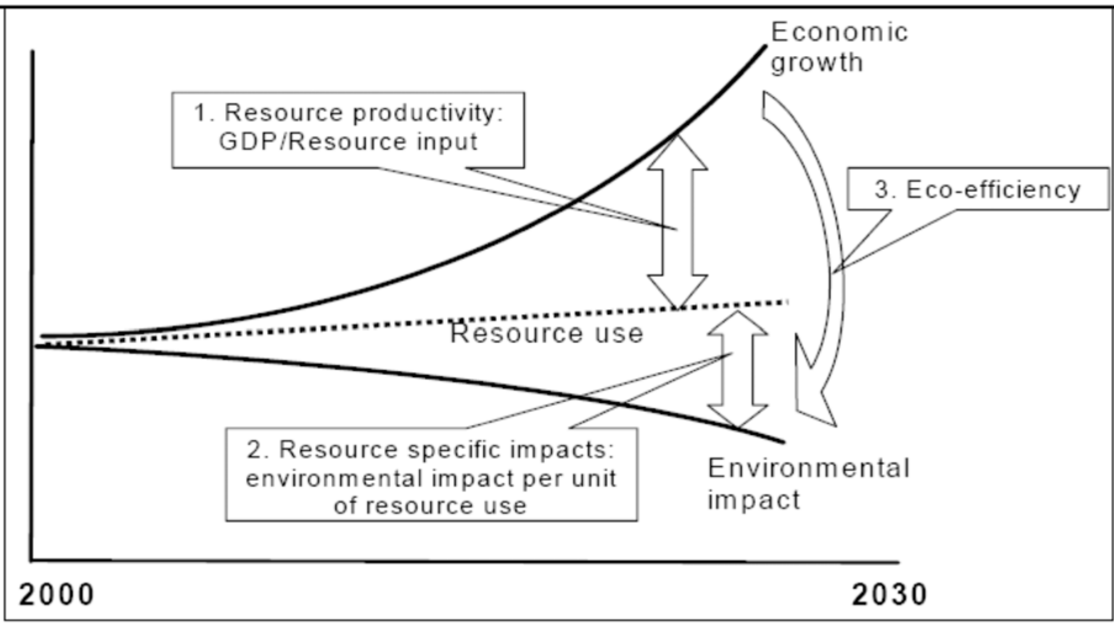
Institute of Environmental Sciences, CML
Leiden University

EU Resource Strategy

- EU Thematic Strategy on the Sustainable Use of Natural Resources: a double decoupling

“Considering that the main drivers of resource use in Europe are economic activities, while at the same time economic growth is a major EU policy objective, the only way to achieve a reduction of environmental impacts is to de-link or decouple environmental impacts from its driver: resource use, and to decouple resource use from its driver: economic growth.”

EU Resource Strategy



Policy Review on Decoupling

- Measuring double decoupling:
  - » Information on resource use
  - » Information on environmental consequences of resource use
- "Policy Review on Decoupling" (CML, CE Delft & Wuppertal Institute):
  - » add environmental dimension to Material Flow Accounts
  - » use life cycle perspective to include impacts in foreign countries
  - » http://ec.europa.eu/environment/natres/titles1_2.htm

Impacts of resource use

- EMC: Environmentally weighted Material Consumption
- Approach: combine info on mass flows with info on environmental impacts
- use MFA database, esp. DMC, for mass flows per material / resource
- use standard LCA database for environmental impacts per material / resource
  - » ETH database (1996)
  - » update presently ongoing: Ecoinvent (2004)
- multiply
- add to one indicator

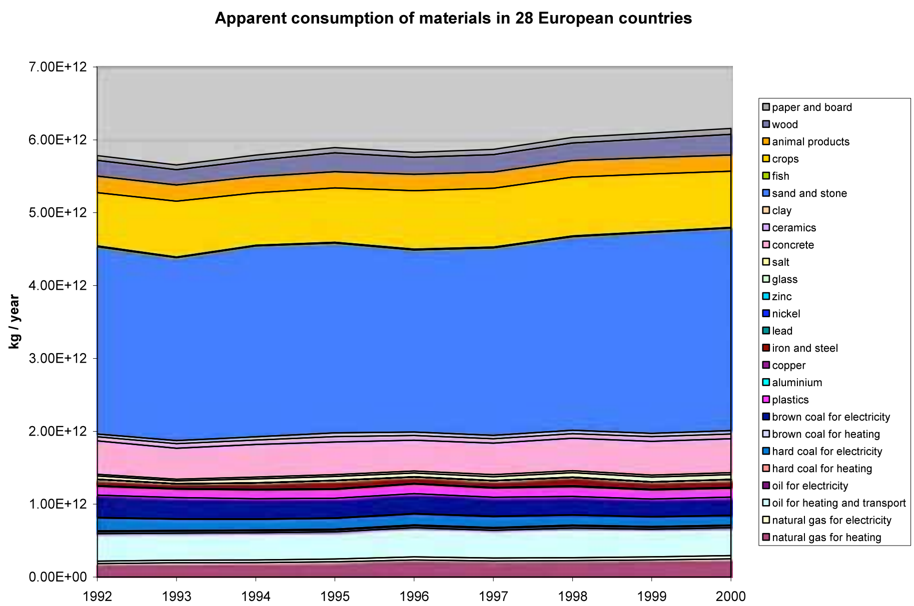
Impacts of resource use

- Material flows:
  - » resource specific: apparent consumption
  - » economy-wide material balances per material
- Impact factors
  - » based on life-cycle approach
  - » with production-consumption chains as starting point
  - » specify chains of materials with environmental interventions at all points
  - » translate into environmental weights: potential impacts per kg of material, for 11 impact categories
  - » can be used as multiplyers for the material flows

Impacts of resource use

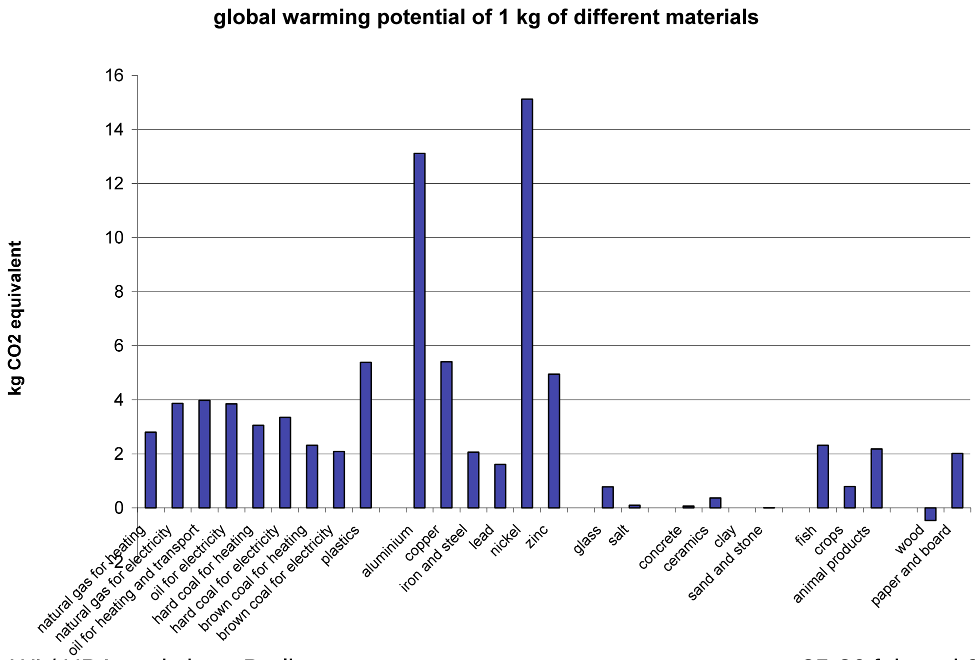
- Midpoint impact categories included:
  - » abiotic resource depletion
  - » land use
  - » global warming
  - » ozone layer depletion
  - » human toxicity
  - » terrestrial ecotoxicity
  - » aquatic ecotoxicity
  - » photochemical smog formation
  - » acidification
  - » eutrophication
  - » radiation

Use of resources and materials



CML-IE

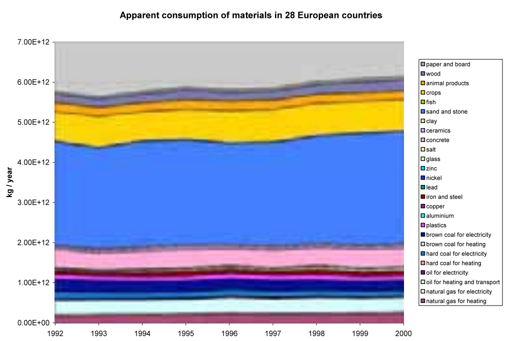
Impacts of resource use



CML-IE

Impacts of resource use

Policy Review on Decoupling: kg x potential impacts/kg = potential impacts



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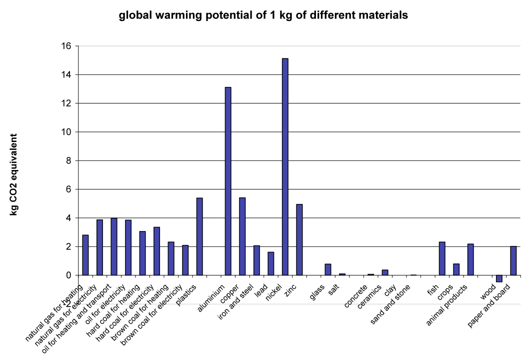
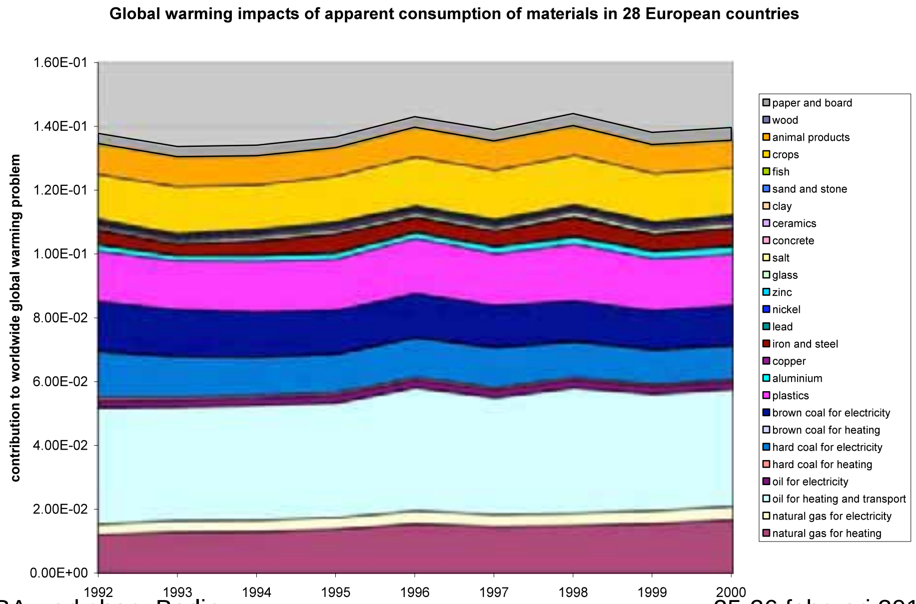
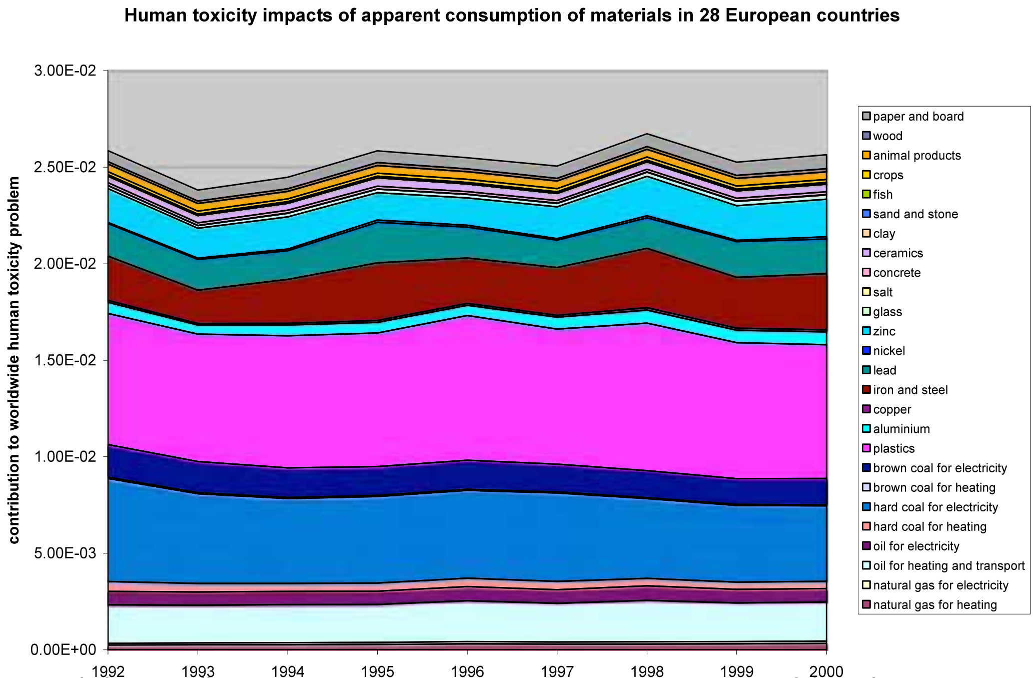


Impacts of resource use

Policy Review on Decoupling: kg x potential impacts/kg = potential impacts



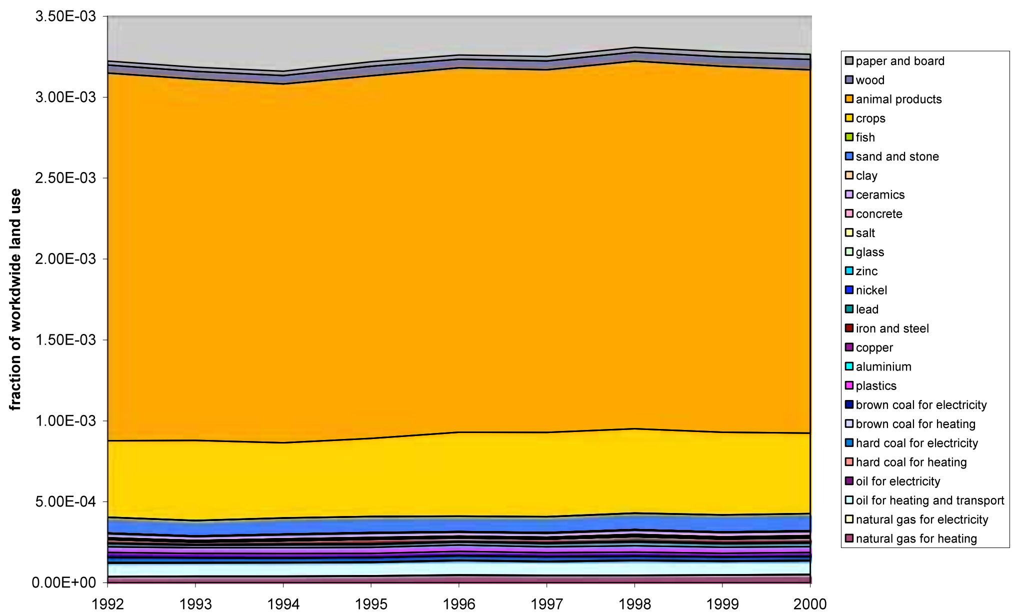
Impacts of resource use



CML-IE

Impacts of resource use

Land use impacts of apparent consumption of materials in 28 European countries



CML-IE

Impacts of resource use

Result:

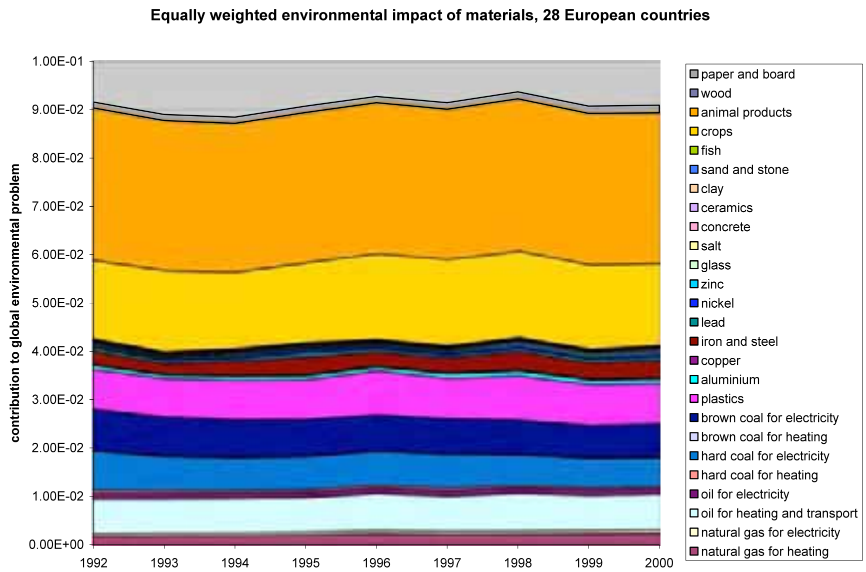
- database with apparent consumption of 33 materials
- database with impacts of materials, in terms of contribution to 11 environmental impact categories per kg material
- a lot of information, can be used for various purposes
- One of which is to derive an aggregate indicator for environmental pressure related to resource use

EMC: Σ flows x impacts

- Eleven scores per material, one for each impact category
- Overall indicator: aggregation needed; problem of weighting (relative importance of impact categories)
- Various weighting schemes available, but none generally accepted
- As an example, equal weighting of problem categories

Impacts of resource use

EMC: weighted total (equal weights)



Further EMC development

- “Basket of Indicators” study (Best et al, 2008) for EU DG Env:
  - » assessment of indicators for reporting on EU resource strategy
  - » four were selected for the “basket: EF, HANPP, DMC, EMC
  - » in addition: LEAC for land use
- Follow-up study for Eurostat:
  - » assess indicators from “Basket” on data requirement and functionality
  - » further develop EMC

http://www.leidenuniv.nl/cml/ssp/publications/eurostat_indicators_final_report_version_141009.pdf

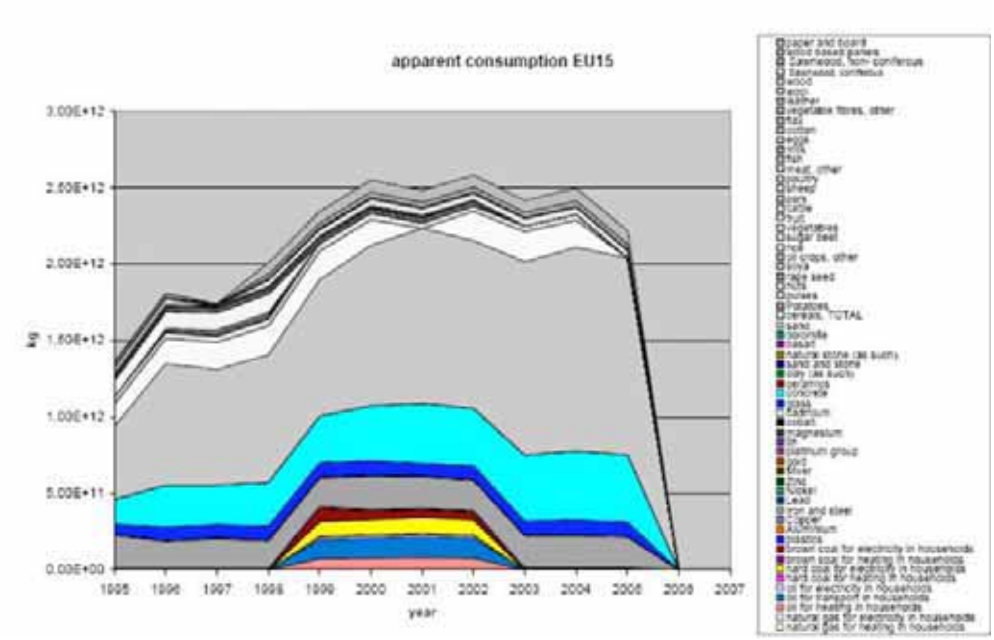
Further EMC development

- Material balances
  - » EMC2005 based on MFA accounts
  - » EMC2009 direct use of EU trade and production statistics
- Impact factors
  - » EMC2005 based on ETH database
  - » EMC2009 update with ELCD inventory data

EMC development: material balances

- Material balances:
  - » Supply balance sheets Agriculture
    - – available and directly usable
    - – allows considerably more detail in biomass materials
    - – time series not always complete
    - – FAOSTAT
  - » Europroms trade and production statistics
    - – in theory, lovely database: detailed information, allows real extension of list of materials (72 instead of 33)
    - – in practice, esp. production statistics very incomplete, not always for apparent reasons
    - – aggregation may also be problematic
    - – MFA accounts, IEA statistics, USGS/other metals and mining reports
  - » Translation protocol developed to avoid double counting

EMC development: material balances

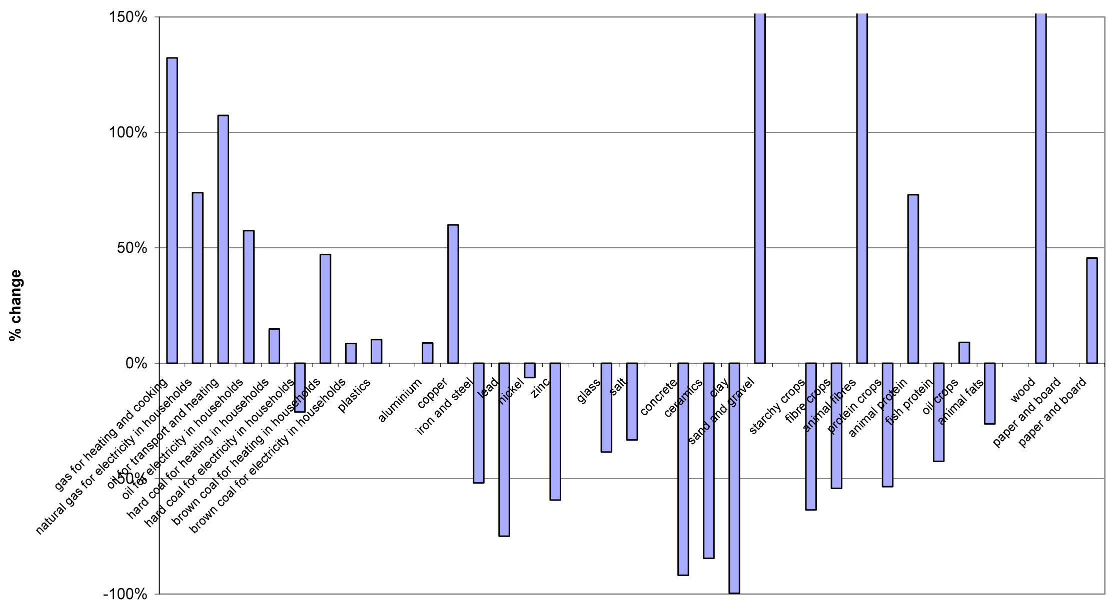


EMC development: impact factors

- Impact factors:
  - » ELCD presently insufficient for LCI of materials, will remain so for the near future
  - » Update of impact factors done with Ecoinvent 2.0
  - » ELCD LCIA procedure not yet available, can be plugged in and applied to LCI at any moment
  - » Guinée et al. (2002) impact categories used; equal weighting

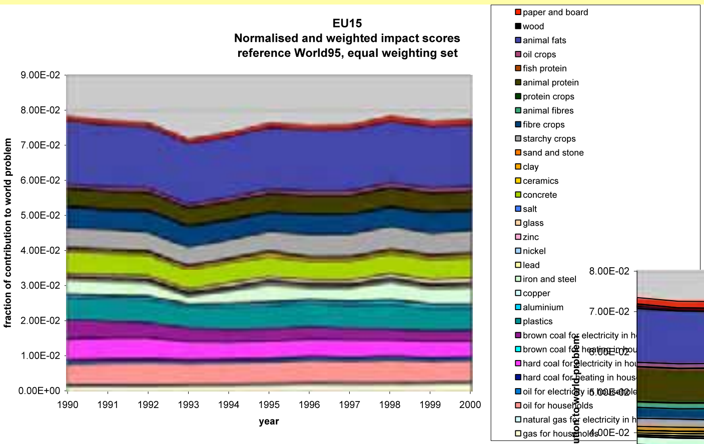
EMC development: impact factors

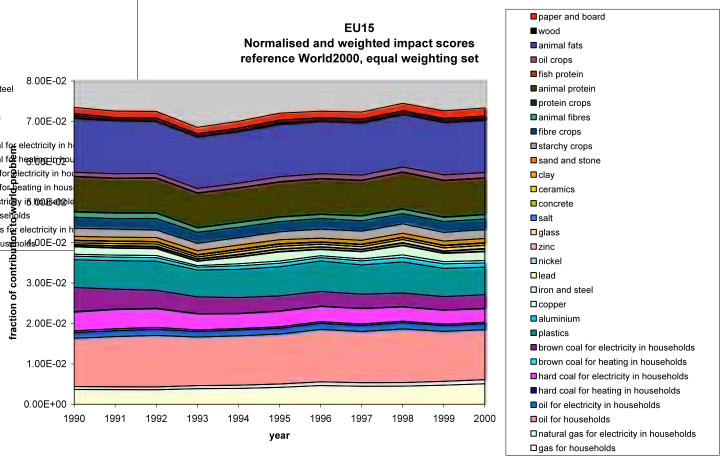
Percentage of change of new impact factor compared to old



CML-IE

EMC development: impact factors





CML-IE

EMC development

- Material balances pose more problems than impact factors
  - » Complete Europroms!
  - » In the meantime, use other databases: FAOSTAT, MFA accounts, IEA statistics, branch information for metals
  - » With those, considerable expansion of list of materials can be realised
- ELCD not yet usable for impact factors
  - » LCI nowhere near completion – in the meantime, other LCI databases can be used
  - » for LCIA, procedure expected in the near future (including weighting)
  - » updates and country/region specific information remain important issues

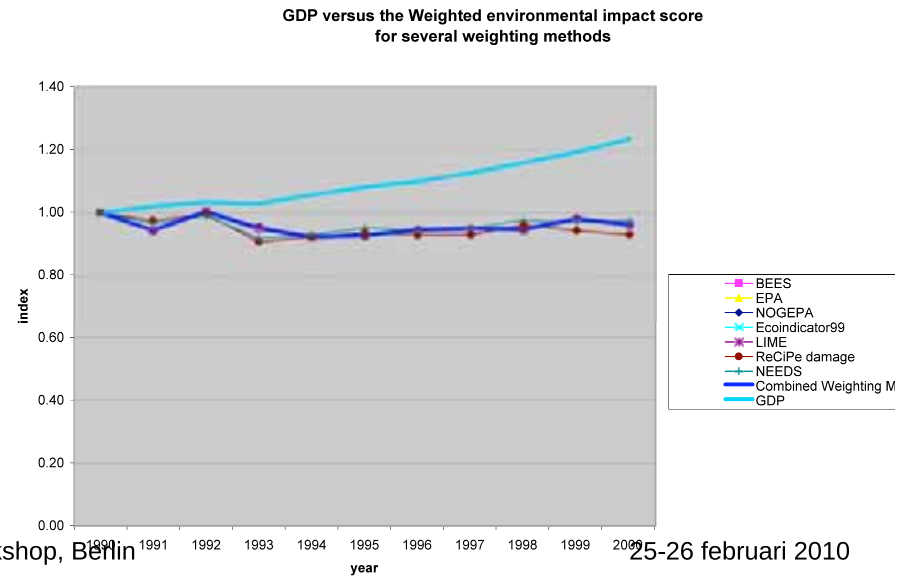
Aggregate indicators: weighting

Weighting / aggregation:

- Tricky business
  - » don't do it at all, but can it be avoided?
  - » depends on purpose:
    - – to measure "de-coupling" aggregate indicator is needed
    - – for most other purposes not
  - » it's better to do it explicitly than implicitly
  - » weighting is an issue for ALL aggregate indicators, even if sometimes hidden
- By definition based on values
  - » requiring political input
  - » challenge is to policy!

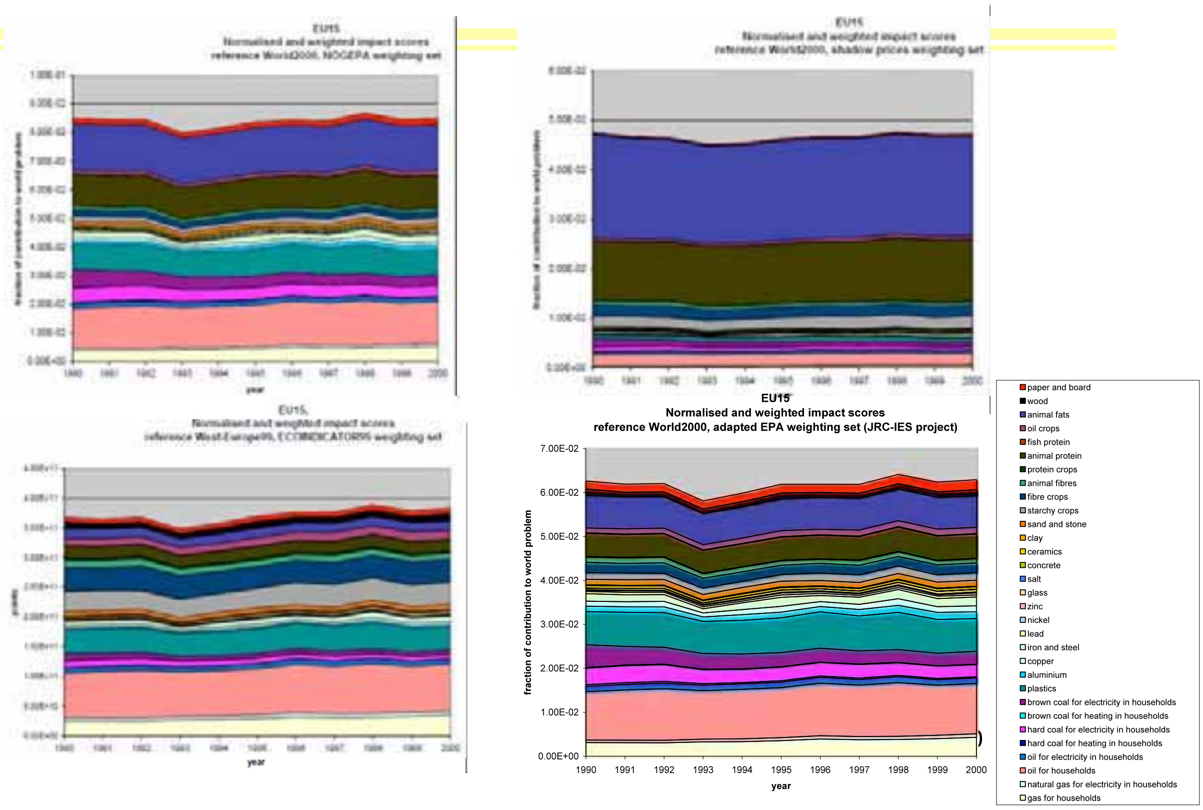
Aggregate indicators: weighting

Weighting / aggregation: study for JRC on weighting: how do different weighting sets work out?



CML-IE

Aggregate indicators: weighting



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CML-IE

Aggregate indicators: weighting

- At aggregate level: EMC is insensitive for weighting scheme
- At desaggregate level: contribution of materials varies ...
- ... but hardly any difference between midpoint-based methods

Use of EMC

- Developed to measure, combined with GDP and DMC, double decoupling
- Based in active research fields: MFA and LCA
- Can be used at aggregate level as decoupling indicator
- Also can be used at desaggregate level
  - » broken down into materials
  - » broken down into impact categories
- Further development
  - » material balances: agreement on data and procedures (Eurostat)
  - » impact factors: agreement on which ones to use (JRC)
  - » aggregation: agreement on weighting scheme (JRC)

Material Use Indicators for Measuring Resource Productivity and Environmental Impacts

Workshop organized by Wuppertal Institute and Federal Environment Agency (UBA)

Berlin, 25.-26.2.2010

Abstracts

The OECD framework of accounting for material flow and resource productivity and recent experiences in Japan

Yuichi Moriguchi
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During last one to two decades, Material Flow Analysis, Accounting and Indicators have made good progress both in methodologies and policy-relevant uses, through interactions between international and national activities as well as those between methodological experts and policy users. OECD has played a key role in these interactions. OECD Council Recommendation (CR) on Material Flows (MF) and Resource Productivity (RP) was adopted twice in 2004 and 2008. Follow-up activities including workshops in Berlin, Tokyo and other capitals have led to outcomes such as a set of OECD guidance documents for measuring MF and RP. Japanese fundamental plan for establishing a Sound Material-Cycle Society adopted three economy-wide MF indicators with their numerical targets in 2003. While indicators have shown successful trend toward the targets, new indicators with/without numerical targets were introduced in the second plan revised in 2008, for better understanding and monitoring of material flows and resource productivity.

Measuring Material Use and Resource Productivity in Europe

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Eurostat

In the past, Eurostat has been fostering the methodological harmonisation of measuring material use in Europe (EW-MFA Guide 2001). Since 2007 Eurostat is collecting EW-MFA data (bi-annually). Currently, Eurostat publishes the DMC indicator as a measure for Europe's material use and resource productivity. In future, Eurostat will extend this indicator towards DMC in raw material equivalents (DMC_{RME}) which is more suited to measure material use and resource productivity.

Measuring DMI, DMC, TMR and TMC of Germany

Helmut Schütz and Mathieu Saurat
Wuppertal Institute

The presentation provides comparative analysis for the most prominent indicators of material input - Direct Material Input (DMI) and Total Material Requirement (TMR), and of material consumption - Domestic Material Consumption (DMC) and Total Material Consumption (TMC). Issues address basic definitions, objectives and foundations, as well as practical application, policy relevance and development perspectives.

Results for Germany 1991 to 2004 show relative decoupling of material resource use from economic growth but no sign of absolute reduction of total global material requirements. Non-renewable materials make up the bigger part of Germany's resource use, in particular fossil energy carriers for domestic consumption and domestic construction minerals. Growing indirect resource use for imports is dominated by metals which is to a large extent exported for consumption in the rest of the world.

Direct material consumption indicates only a relatively small portion of total global resource requirements for Germany's domestic consumption.

Sensitivity analysis of the indirect flows of imported metals showed high probability of the results for TMR.

DMI and DMC of Germany calculated as Raw Material Equivalents

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Federal Statistical Office of Germany

Within material flow accounts the indicators known as DMI (Direct Material Input) and DMC (Domestic Material Consumption) are calculated. The main question according these indicators is: how to take into the account the whole material content of imported goods (respectively exported goods). DMI, which includes imported goods in tons, underestimates the real material input of the economy. The Federal Statistical Office of Germany produced a first estimation of DMI and DMC in raw material equivalents (RME). This method tries to integrate the imported goods in form of raw materials directly and indirectly used in the manufacturing and transport process.

The basis for the calculation is a hybrid input-output approach, combined with the coefficients of life cycle analysis for those products, which are not produced in Germany at all or which are manufactured abroad under completely different conditions. As an additional part of RME-calculation, raw materials used for the transport of traded goods were estimated.

The first results were calculated for imports, exports, DMI, DMC and physical trade balance for time period 2000 – 2007.

Accounting for Environmental Impacts of Resource Use - Outline of a challenge and recent approaches

Stefan Bringezu
Wuppertal Institute

The decoupling of resource use and environmental impacts at macro level can only be measured if valid methods are available. Starting point is the system definition delineating the resources, materials and products used for which specific impacts are then determined in a life-cycle-wide perspective. For this purpose, bottom-up approaches with selected materials, input-output-approaches, and hybrid approaches can be applied. Single specific impacts of overall resource use (production and consumption) such as global warming potential (GWP) can be accounted with reliable certainty. However, accounting for various other specific impacts is still difficult and bound with uncertainty. The characterization and quantification of important LCA impacts categories is still lacking or based on disputable assumptions (e.g. depletion of resources). The aggregation to single indexes requires additional normative assumptions. Macro approaches with reliable LCA elements seem promising to derive key indicators (e.g. global land use change).

Environmental weighting of resource use

Ester van der Voet
CML

The Environmentally weighed Material Consumption (EMC) indicator has been developed for the EU DG Environment, to support their Resource Strategy. This Strategy aims at double decoupling: (1) economic growth from resource use, and (2) resource use from environmental impacts. While mass-based indicators such as DMC and TMC can be used for the former, the EMC is developed for the latter. The idea is to develop multiplyers for materials based on their life-cycle wide environmental impacts. The consumption of those materials weighed by the multiplyers and added to a total then is the EMC. For the material consumption, MFA data can be used – a direct use of production and trade statistics is preferable but at EU level statistics are as yet too incomplete to be meaningful. For the impact multiplyers, LCI data are used from the Ecoinvent database and translated into 11 midpoint impact categories. These in turn have to be aggregated via normalisation and weighting to arrive at one indicator. Both for the LCI data and for the aggregation, various options are available. Harmonisation within the EU is an ongoing process. EMC is presently considered as one indicator in a basket of decoupling indicators, to be compiled by Eurostat on a regular basis in their Datacenter for Natural Resources.